**DOCTOR OF EDUCATION**

# Primary children's attitudes towards electronic games and effect of electronic games on primary children's mathematics learning

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## DECLARATION

I declare that this thesis is my own work under the direct guidance of Professor David Miller and Dr Elizabeth Hannah as part of my study for the award of PhD Degree at the University of Dundee, Dundee, Scotland.

This thesis has not been published or submitted in support for the award of any degree or qualification at any other institution.

# ABSTRACT

Electronic game playing is a very popular activity for children today. In the last few years there has been much attention to the potential of using games for learning. Though there have been some negative sides to electronic game playing – such as the claim that game playing is linked to aggressive or addictive behaviours (Sandford & Williamson, 2005) – a number of empirical studies suggest that games can be a tool for learning (e.g. McFarlane, Sparrowhawk & Heald, 2002, Miller & Robertson, 2010, 2011).

The purpose of this thesis was to investigate children's attitudes towards electronic games in Scotland and China and examine the effects of mathematics electronic games on the mathematics achievement and mathematics attitudes of primary school students. In the first part of the research, a total of 44 students from one primary school in Scotland and 127 pupils from two primary schools in China participated in the study investigating their attitude towards electronic games. This study found that electronic game playing was a very popular activity for both Scottish and Chinese children and they had positive attitudes towards electronic games. Children were motivated by the fun aspects most. However Scottish children spent more time on gaming than Chinese students. Moreover, Scottish children tended to regard games primarily as a source of enjoyment and for entertainment, while games seemed to be a learning medium besides fun for Chinese students.

The second part of the study examined the effects of a mobile phone game 'Brain challenge' on Primary 4 students' achievement in mathematics and on students' attitudes towards mathematics. An experimental control-group design with repeated

measures analysis was employed to explore mathematics performance and attitude differences within groups at three time points. A sample of 17 students was randomly assigned to treatment and control groups. In the first three weeks, the mobile phone game group children played a mobile phone game for fifteen minutes in the classroom daily and the other group of children acted as no-treatment controls. For the next three weeks, all children played the mobile phone game for fifteen minutes every weekday. Mathematics performance data were collected at the start, after three weeks and at the end of the study. In addition, interviews were conducted with the students and the class teacher to provide extra data to help explain the results of the quantitative data. The findings provide evidence to show a positive effect in speed of computation and percentage accuracy rate after playing a mobile phone game in a longer 6-week period. No significant difference was found in mathematics attitude after playing the mobile phone game.

The final study attempted to address one of the weaknesses of much research in the area of game based learning: the fact that many studies use no-treatment controls. Fifteen Primary 3 students were divided into two groups by stratified random assignment. Both groups were involved in learning the same mathematics processes. They used either a technology-based online electronic game or a paper-based card game for 4 weeks and then swapped conditions for another 4 weeks. The methods used were similar to the mobile phone game study, a pre-post design measuring performance and attitudes together with in-field observation to provide extra information when interpreting the results of the quantitative data. Results from this study were somewhat mixed: it was found that the online electronic game positively impacted on children's mathematics

attitude. The improvement in children's mathematics performance from the card game was significant. In contrast, no significant gains were found in students' mathematics performance after online flash game playing. When a between-group analysis was conducted, there was no significant difference between the two conditions.

The overall results provide some evidence that electronic games can be an effective learning tool to improve primary school children's mathematics skills and mathematics attitudes. However not all the findings supported the use of electronic games, although some aspects of the methodology could have influenced the findings, such as small sample size, short intervention times and problems with treatment fidelity. There are implications for teachers and for future research into game-based learning.

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# ABBREVIATIONS

| | |
|---|---|
| ATMI | Attitudes towards Mathematics Inventory |
| BBC | British Broadcasting Corporation |
| BECTA | The British Educational Communications and Technology Agency |
| CfE | Curriculum for Excellence |
| COTS | Commercial-Off-The-Shelf |
| HMIe | Her Majesty's Inspectorate of Education |
| Ofcom | The Office of Communications |
| TEEM | Teachers Evaluating Educational Multimedia |
| UK | United Kingdom |
| UREC | University of Dundee Research Ethics Committee |
| US | United States of America |

# CHAPTER 1 INTRODUCTION

## 1.1 INTRODUCTION

This thesis is about the use of electronic games for learning purpose. I first noticed that games could play a role in my own learning when I first used a computer game in one module when I studied computer science at the university. I learned how to memorise the keyboard and type quickly, using a computer game. I realized how effective it was in terms of helping me to remember the alphabets and use the keyboard better than before. Of course, I could have learned these skills from a manual, but using a game made it more fun, and it was effective. From that moment forward, I was convinced that computer games could be invaluable for learning, and I became interested in studying the area of game based learning.

The rate of change in ICT is accelerating in all areas, not least in electronic or digital games. These games can be played at home, at school, in the car and on various platforms. We can play games on a computer, on television, on the mobile phone or on a game console. In addition, with the development of technology, Java games and Flash games have become increasingly popular. The main advantage of using Java or Flash is that it is simple to make games and games can be played through a web browser or standalone on personal computers or mobile phones.

In recent years, with the development of technology, there has been increasing interest in the use of information and internet technologies, both in the potential of computer games as learning and teaching tools, and in research into their use. Computers are used within everyday school practice in many primary schools throughout the world. They can be used in multiple ways in a classroom (Rodrigues, 1997; McFarlane, 2002). Especially, the use of electronic games in education has become a popular topic and there is increasing interest in the use of electronic games in the classroom and how it can help learning.

In the past, electronic games have been dismissed as a distraction from more ‘worthy’ activities, such as homework or playing outside (Kirriemuir & Mcfarlane, 2004). However, whilst there has been an ongoing argument about the advantages and disadvantages of playing electronic games for education, as electronic games are popular recreational activities for young people today. A survey by the British Broadcasting Company (BBC)'s Audience Research department found that almost hundred percent children between the ages of 6 and 15 had played an electronic game on various game systems at least once in the last 6 months, 95% had played several times a week and 61% had played every day (Pratchett, 2005).

Many educators and researchers have been interested in using electronic games in an educational setting to enhance learning outcomes (e.g. Prensky, 2001; Gee, 2003; Squire, 2003). A number of negative issues associated with the use of games for learning have been raised. These include the fact that the use of games can be seen as encouraging sedentary behaviour and may lead to aggressive and addictive behaviours (Sandford & Williamson, 2005), put children at risk of obesity (Subrahmanyam, Kraut, Greenfield, & Gross, 2000) or may negatively affect academic performance because of frequent electronic game playing (Roe & Muijs,1998; Gentile, Lynch, Linder, & Walsh, 2004)

However, a number of empirical studies exist that suggest that games could be an effective tool for learning. For example, game playing can improve students' critical thinking (Amory, Naicker, Vincent, & Adams, 1999), problem solving skills (McFarlane, Sparrowhawk, & Heald, 2002), visual-spatial skills (Green & Bavelier, 2007) and academic performance in learning mathematics (Miller & Robertson, 2010, 2011), learning geography (Tuzun, Yilmaz-Soylu, Karakus, Inal, & Kizilkaya, 2009), learning English (Yu, Chang, Liu, & Chan, 2002), and learning computer science (Papastergiou, 2009).

There are many studies into using electronic games for mathematics learning. Mathematics is used every day in our daily life and mathematics ability is important for us to function effectively in society and relate to our future career. Mathematics is a significant component of the curriculum in most countries. It is clearly important to learn and it seems reasonable to argue that it should be taught through interesting and enjoyable methods. However, mathematics has predominantly been taught through textbooks at school (Harries & Sutherland, 1999). The use of games provides an ideal opportunity to make connections with children that get them learning in a fun way. Oblinger (2004) says:

> "Oftentimes students are motivated to learn material (e.g., mythology or math) when it is required for successful game play – that same material might otherwise be considered tedious." (p. 13)

## 1.2 STATEMENT OF THE PROBLEM

In a recent survey, 36% of primary school teachers and 27% of secondary school teachers said that they had used games to teach (Sandford, Ulicsak, Facer & Rudd, 2006). Although there is support for the idea that electronic games have a positive effect on children’s learning, there have been mixed research results regarding the role of electronic games in promoting mathematics achievement and mathematics attitude in the primary classroom. For example, in a meta-analysis, Vogel, Vogel, Cannon-Bowers, Bowers, Muse and Wright (2006a) examined 32 empirical studies and concluded that the inclusion of games for students’ learning resulted in significantly higher cognitive gains compared with traditional teaching methods without games. Miller and Roberston (2011) tested the effects of Nintendo games by incorporating them into the primary classroom and found significantly positive results in the students’ mathematics performance. Similar positive effects were observed in mathematics performance by Ke and Grabowski (2007). They tested the effects of cooperative computer game-playing on the math achievement of 125 5th-graders compared with competitive game-playing and non-game-playing groups. The authors observed significantly higher improvement in math performance in both computer game-playing groups compared with the non-game-playing group.

However, other studies have not shown the same positive effects of games. Ke (2008b) examined the effect of educational mathematics computer games during the summer math camp on 4th- and 5th-graders’ mathematics learning. At the post-test, the author found no significant effect of computer games on math achievement. In another study, Fuchs, Fuchs, Hamlet, Powell, Capizzi and Seethaler (2006) found a mixed result of using game for 33 first grade students. The mathematics game was effective in promoting addition but not subtraction number combination skill. Therefore it appears that despite increasing interest in computer games, there has been no consensus on their effects on academic achievement. Moreover, as will be described in Chapter 2, there have been several gaps in the literature. For example, many of these applications are expensive - very few research studies have looked at using low-cost mobile phone games as alternative learning tools. Another key problem with the research is that few published studies have employed a control group where the participants have been involved in similar conceptual learning; many of them have used no-treatment controls, and very few have contrasted traditional and technology-based learning conditions for primary children in mathematics learning. To increase knowledge in this area, the current study empirically examined the effect of a low cost mobile phone game in primary school on mathematics learning and compared the effectiveness of using technology-based online game and a paper-based card game with the same learning goals for primary school children's mathematics learning in the classroom. These were preceded by questionnaire survey to learn more about children's views on electronic games.

## 1.3 AIM OF RESEARCH

Rodrigues (2010) suggested that as a researcher you should make sure you clearly and explicitly express the study's principal aims and objectives at the beginning of the research. The aim of this research study is to investigate the views of children about electronic game playing and examine the evidence for and against the use of electronic games in mathematics learning. The thesis looks especially at their use with students in primary school.

## 1.4 DEFINITION OF TERM 'ELECTRONIC GAMES'

In this thesis, it should be noted that, unless otherwise specified, the term 'electronic games' will be used here generically to include games played on computers as well as games played on game equipment such as video game console, mobile, and hand-held machines.

This thesis employs the term "electronic games" to represent all the games on all the game systems such as PC, Playstation, Xbox, Nintendo's, PSP, Gameboy, and mobiles. There are several reasons to choose the term "electronic games" rather than "computer games", "video games" or "digital games":

1. All the game systems use electronics to create an interactive system and then the player can play on it.
2. The term "computer games" traditionally referred to the games which are played using a personal computer.
3. The term "video games" can be used to describe the games which are played using a video display.
4. Some of the earlier games were played using analogue-based computers, so these kinds of games cannot be included in digital games.

## 1.5 CONTRIBUTIONS

The main contributions of this thesis are the following:

- There has been much interest in children's electronic gaming culture, well documented in education in the West, while research in a cross-cultural context was lacking. The present study contributes to our knowledge by investigating the views of children in China as well as Scotland.

- This thesis contributes further insights to the existing literature of computer game effectiveness as it differs from most previous studies with regards to the type of game used, the research design and the methods. The key features of the design will be outlined in Chapters four, five and six.

- Very little research has been undertaken on using a mobile phone game and its impact on student achievement in the primary school classroom. The findings of this research add to the existing body of knowledge by providing evidence that the use of a mobile phone game positively impacts elementary students' mathematics learning with a group of students in Scotland.

- There was very little research comparing the impact of online games and paper-based games on children's mathematics learning in the primary school classroom. The results of this study add to the existing body of knowledge here.

- At a practical level, the findings can inform schools or teachers who are going to start integrating electronic games into the classroom.

## 1.6 STRUCTURE OF THE THESIS

> "…All research texts must consist of five sorts of information that readers need access to: about the focus of the study, about the case investigated, about the methods employed, about the main claims made and the evidence offered in support of them, and about the conclusions drawn" (Hammersley, 1995, p.96)

This thesis contains eight chapters in total. This initial chapter is the Introduction to the thesis, which provides an overview of the motivation for the project and the influences on this research and then states the aim of this research and summarizes the contribution to knowledge arising from this work. The following section describes how this thesis is organised.

Chapter 2 provides a review of literature on mathematics learning and games, which draws on work in the fields of learning and teaching mathematics in primary education, and describes the previous work about using computer games in learning, especially in mathematics learning. This chapter defines the terminology used throughout the thesis, considers the importance of attitudes, and in particular attitude towards mathematics and games, discusses the nature of gaming and engagement, and looks at evidence of learning mathematics with games in the primary school classroom.

Chapter 3 describes the key issues emerging from the literature review and proposes the main research questions for this thesis. It also provides a brief overview of three studies that were conducted, the research methodologies used and the reasons for these choices. Following this, a summary of some key aspects of inferential statistics is presented. Finally the ethical considerations arising from the research design are stated.

Chapter 4 discusses the rationale, the methods and techniques employed, and the findings of the first study about investigating children's views on electronic games in Scotland and China. The discussion of the results is reported in the final part of this chapter.

Chapter 5 discusses the study examining the effects of a mobile phone game 'Brain challenge' on Primary 4 students' achievement in mathematics and on student attitude toward mathematics. The methods and techniques employed in this study are stated; they involved data from several instruments: mathematics test, mathematics attitudes questionnaire, mobile phone game questionnaire and interviews. The findings and discussions of this study are presented at the end.

Chapter 6 discusses the study investigating the effects of an online electronic game on Primary 3 students' achievement in mathematics and on student attitude toward mathematics, and the difference between using a technology-based electronic game and using a non-technology, paper-based card game. The methods, materials and techniques employed in this study are stated and the findings and discussions are presented.

Chapter 7 discusses the key issues emerging from the three studies conducted in this thesis and reviews the main research questions. The limitations of this thesis are described.

Finally, Chapter 8 provides the conclusions of the thesis following on from the findings of the previous chapters, particularly considering the implications of using electronic games for mathematics learning in the primary school classroom. This chapter also provides my personal reflections on my PhD study and considers future directions for this research.

In summary, this thesis presents an account of the field of electronic games in primary mathematics learning, and describes a range of research activities undertaken in this area. The thesis attempts to answer all the research questions emerging from the literature review and draw the findings together to gain a greater understanding of how electronic games can be used most effectively to support children's mathematics learning in primary school classroom. Finally the thesis also makes some suggestions for further work as well as identifying some implications from the study.

# CHAPTER 2 LITERATURE REVIEW

In this chapter the researcher provides a review of published literature relating to the use of electronic games for learning and in particular mathematics learning. This review is divided into four sections. First, there is a review of literature relating to children's electronic game playing. This will include children's electronic game use pattern, game type preferences, social contexts of game playing, children's motives for game playing, children's mobile phone use and cross-culture studies in UK and China. Second, there is a discussion of the literature based on theories in game and learning. Third, there is a review of children's numeracy learning especially in mental calculation. Then the literature about attitudes towards mathematics and using electronic games for learning in the classroom will be discussed. Finally, there is a section which discusses the evidence from some empirical works related to using games for mathematics learning in the primary school as well as their limitations.

## 2.1 CHILDREN'S ELECTRONIC GAME PLAYING

In today's society, with the rapid development of technology, digital media have become one of the most important ways to entertain people, and change the way of their thinking, living and learning. Most adults and teachers are not born into the digital world but may have become attracted and adopted the new technologies. They are classed by Prensky (2001) as "digital immigrants". In contrast, today's children who have been involved in and use digital media from an early age have been grouped as "digital natives". The digital immigrant teachers cannot use the same methods for their students that worked when they were students because “today’s learners are truly different.” (Prensky, 2001, p.100). The thinking and learning of digital natives has changed a lot over the last few years (Prensky, 2001). In order to give the digital natives a meaningful education, Prensky (2004) stated that teachers need to learn about the digital natives’ ways of thinking and learning:

> “… in a short time technology has changed an entire generation’s behaviour radically, and it behooves all of us who are not from that generation but whose daily life involves interaction with them, such as parents and teachers, to learn as much as we can about the new behaviours.” (p.13)

Nowadays, playing computer game has become massively popular and a mainstream activity amongst the young children (Williamson, 2009). So understanding about children’s usage of and opinions about electronic games is essential for those interested in using computer games as a potential learning tool.

### 2.1.1 CHILDREN’S ELECTRONIC GAME USE

Today’s young children live in a media rich environment (Roberts, 1999). Roberts (1999) conducted a study of the media environment and media habits of 3155 sample US children aged 2 to 18 years. Seventy percent of children had a video game player at home and 18% lived with three or more video game players. The ownership of video game players increased in a later study of over 2,000 8 to 18 years children. The researchers found that 83% of them had at least one video game player in their home, 31%

had 3 or more video game players in their home, and 49% had video game players in their bedrooms (Roberts, Foehr, & Rideout, 2005). Similarly, a study with over 1536 children in UK found that half of children aged 8-15 years owned a game console at home (The Office of Communications [Ofcom], 2006). Playing electronic games was a popular leisurely activity for children (Robertson & Good, 2005). There have been many published studies to identify the use of children's electronic game playing worldwide (e.g. Fromme, 2003; Roberts, et al., 2005; Pratchett, 2005; Chou & Tsai, 2007; Yun, Shi, Wang, Zhang, Wang, & Li, 2008). Electronic games were "the most frequently used interactive media" (Beentjes, Koolstra, Marseille, & Van der Voort, 2001, p.95). From a study conducted by the BBC's Audience Research department in the UK, the youngest age group (6-10 years) is extremely dedicated to their gaming. One hundred percent of them are gamers who had played a game on a mobile, handheld, console, PC, Internet or interactive TV at least once in the last six months, 95% playing several times a week and 61% playing everyday (Pratchett, 2005). Yun, et al. (2008) surveyed 2571 students and found 83.5% Chinese young people had played electronic game before. Young people were willing to spend large amounts of their time to playing games. Fromme (2003) conducted a European comparative study in 1997 and 1998 and found that young people aged between 6 and 16 years spent on average 32 minutes per day playing electronic games. Children and adolescents aged 8 to 18 years in the US spent 49 minutes on video games daily in Roberts, et al.'s (2005) study. There has been a steady increase in the amount of time children spend playing video games from 49 minutes daily in 2005 (Roberts, et al., 2005) to 1 hour 13 mins in 2010 (Rideout, Foehr, & Roberts, 2010). A study from the UK recently indicated that children aged from 8-11 years spent average 8 hours per week on electronic gaming since 2008 (Ofcom, 2012).

This makes it possible to conclude that electronic games occupy an important place in young children's life.

There have been a number of studies investigating possible gender difference in electronic game play. Gender has no significant impact on whether someone is a gamer between 6-10 years, with 52% males to 48% females (Pratchett, 2005). However the interest in electronic gaming may change when children get older. Fromme (2003) hypothesizes that girls generally lose some interest in computer games as they get older and use PCs for other uses such as school work or sending emails, while boys still mainly use PCs as games machines throughout their childhood and teenage years.

Research into the different patterns of usage between males and females has found that male children spend more time playing electronic games than females (e.g., Buchman & Funk, 1996; Funk, Buchman, & Germann, 2000; Fromme, 2003; Sweeting & West, 2003; Bonanno & Kommers, 2005; Chou & Tsai, 2007). However, the gender discrepancies in time spent playing video games may be diminishing as electronic game play becomes more and more popular. One study found that boys ages 8 to 18 years were spending three times as much time as girls playing video games (Roberts, Foehr, & Rideout, 2005) but this difference has decreased in recent years as boys were found to spend twice as much time as girls playing videogames five years later (Rideout, Foehr, & Roberts, 2010).

### 2.1.2 GAME GENRE PREFERENCES

There is well-documented research about gender difference in game genre preference such as studies in the 1990s (e.g. Inkpen, et al., 1994; Kafai, 1996; Miller, Chaika, & Groppe, 1996; Subrahmanyam & Greenfield, 1998) and recent research (e.g. Sherry, Lucas, Greenberg, & Lachlan, 2006; Chou & Tsai, 2007; Dawson, Cragg, Taylor, & Toombs, 2007; Jenkins & Cassell, 2008; Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010; Procci, Bohnsack, & Bowers, 2011). All the studies showed that boys and girls have some different game interests and play different types of game. For instance, Fromme (2003) found action and fighting games were boys' most favourite games and platform (Jump and run) games were girls' most favourite games; McFarlane, Sparrowhawk and Heald (2002) stated that the most popular games genre was adventure games for boys and girls; and Griffith (1997) showed that the most frequently played game types by boys were role-play games and puzzle games for girls. Lucas and Sherry's (2004) studies showed that males prefer racing/speed, sports, physical enactment, shooter and fighter games most whereas females prefer puzzle, quiz/trivia, arcade, card/dice games as well as classic board games. Dawson et al. (2007) supports the results of Lucas and Sherry's (2004) study and found that girls were less likely to play games based on shooting, fighting or sports, although these differences were not universal.

However, because there is no standard categorisation of games and a variety of genres have increasingly come with more complex games (Kirriemuir & McFarlane, 2004), different studies used different game typology. So there were some differences in reporting children’s favourite game type between the above studies. For example, Fromme (2003) grouped the games into seven categories as proposed by Fromme, Meder, & Vollmer (2000): Platform (Jump and run), Action, Sport, Think and puzzle, Adventure, Racing and Simulation, strategy. Griffith (1997) listed 9 categories for children to choose: Sports simulations, Racers, Adventures, Puzzlers, Weird games, Platformers, Platform blasters, Beat ’em ups and Shoot ’em ups.

### 2.1.3 SOCIAL CONTEXTS OF GAME PLAYING

Fromme (2003) found some information about the social context of children’s computer gaming culture and stated that electronic games were mainly connected to peer relations and friends were the most important advisers and mediators for acquiring game information. The role of parents seemed not to be important because children preferred to play with friends or brothers/sisters than parents. In Fromme (2003), the sample children stated that they were able to discuss the game with friends, to get help or advice or share the feedback from each other or to compete with friends. More recently, Dawson et al. (2007) confirmed this finding that “gaming is an important talking point within peer groups” (p.10) and children liked sharing their video game experiences and talking about video games with friends.

Ulicsak and Cranmer (2010) have indicated that children felt it was more fun without an adult and explained that young people wanted independence to play games away from parental supervision. On the other hand, an early study conducted by Mitchell (1985) suggested that playing games was an important part of family play and electronic games brought the family members closer together for sharing game play and interaction. This difference might be because the electronic game was new to families in the 1980s but now the games have become more common in the home.

Fromme's (2003) study showed that children can be integrated into active peer groups through playing electronic game together and electronic gaming did not lead to social isolation. This finding is in line with other studies from Pratchett (2005) and McFarlane, Sparrowhawk, and Heald (2002)'s work. Pratchett (2005) stated that young children (6 to 10 years) were the most sociable players and 54% of interviewed children said they preferred playing games with others rather than on their own. McFarlane, et al. (2002) also showed that pupils were more likely to play games with one or more friends than on their own. However one study from the UK by Dawson, Cragg, Taylor, and Toombs (2007) proposed a different explanation. They indicated that gamers chose to play on their own or with others, depending on the different games and different players. They explained that gamers often prefer to play games on their own because they can become immersed in the game without distractions. But sometimes they like to play together because it can be more fun with friends and they liked the "competitive ambience" (p.42) when playing sports games or multiplayer online games. However this different finding maybe arose because of the nature of their sample. The sample in Dawson et al.'s (2007) research covered a broader age spectrum (7 to 40 years). In contrast, the samples in research from McFarlane, Sparrowhawk, and Heald (2002), Fromme (2003) and Pratchett (2005) were only concentrated on young people.

### 2.1.4 MOTIVES FOR GAME PLAYING

There have been many research studies about the motivations for game playing (e.g. Malone, 1981; Phillips, Rolls, Rouse, & Griffiths, 1995; Griffiths, 1997; Vorderer, Hartmann & Klimmt, 2003; Kirriemuir & Mcfarlane, 2004; Lucas & Sherry, 2004; Sherry, Lucas, Greenberg, & Lachlan, 2006; Funk, Chan, Brouwer, & Curtiss, 2006; Dawson, Cragg, Taylor, & Toombs, 2007; Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010; Chou & Tsai, 2007; Olson, 2010) but no clear consensus emerges on the reasons why people play electronic games (Kirriemuir & Mcfarlane, 2004). Possible reasons for these inconsistent findings are that different researchers used different methods to collect data such as questionnaires (e.g. Phillips et al., 1995; Griffiths, 1997; Fromme, 2003) or interviews (e.g. Funk, et al., 2006; Dawson, et al., 2007); or asked different questions in the interviews or questionnaires; or investigated different age groups from young children to adults. For example, Fromme (2003) collected data from 7 to 14 year old primary school children. Chou and Tsai (2007) conducted a survey for high school students from 15 to 18 years and Lucas and Sherry (2004) collected from 18-24 year old college students.

A number of researchers have found that children are motivated by the fun elements of games (e.g. Griffiths, 1997; Kirriemuir & Mcfarlane, 2004; Dawson, et al., 2007; Olson, 2010). For example, Kirriemuir and McFarlane (2004) stated four main reasons why children play computer games. These results were from a survey carried out by the Entertainment Software Association in 2001. Eighty-seven percent of children said they played computer games because it is fun. Seventy-two percent of children found computer games to be challenging to them and 42% said they enjoyed playing computer games because they could share the social experience with friends and family. Thirty-six percent of the children thought games provided long time periods of entertainment value for the money. The main contributing factor is fun. Prensky (2001) suggested that the 'fun' aspect in games is the greatest motivator. As he stated: "The true twenty-first-century learning revolution is that learning-training and schooling-is finally throwing off the shackles of pain and suffering which have accompanied it for so long. Within most of our lifetimes pretty much all learning will become truly learner-centered and fun-fun for students, fun for trainers and teachers, fun for parents, supervisors administrators and executives" (Prensky, 2001, p.14)

From the above studies, it seems that a sense of fun is a great motivator, but fun may not be the only factor that keeps players interested. Reasons such as competition, challenge, social interaction, alleviate boredom, and fantasy also motivate children to play electronic games (e.g. Malone, 1981; Phillips et al., 1995; Prensky, 2001; Lucas & Sherry, 2004).

- Competition: There were some studies that found that children were motivated by competition (e.g. Malone, 1981; Malone & Lepper, 1987; Subrahmanyam & Greenfield, 1998; Papert, 1998). Papert (1998) stated that the competitive nature of games will keep children playing persistently. Trying to be the first one to master a game or to be the best player of the game was a powerful incentive for children to learn and learn fast.

- Challenge: There were also some studies that found that children were motivated by challenge (e.g. Inkpen, et al., 1994; Garris, Ahlers, & Driskell, 2002; Lucas & Sherry, 2004; Kirriemuir & Mcfarlane, 2004; Funk, Chan, Brouwer, & Curtiss, 2006). Malone (1981) argued that "in order for an environment to be challenging, it must provide goals whose attainment is uncertain" (p.50). Goals should neither be too easy nor impossible to achieve. Eccles and Wigfield (2002) believed that children become motivated if challenging goals are set according to an individual's ability and then they will become more self-motivated. Prensky (2002) claimed that a game needs to provide different levels and require the player's effort to finish the task but the continuous challenge in a game should be combined with precise context and user appropriate level to keep the player engaged. Lucas and Sherry (2004) also found that players will be highly motivated to play video games by challenge such as pushing one's self to beat the game or getting to the next level.

- Social interaction: Most games can provide opportunities for a connection to other players which allow the players to cooperate in person or play with remote peers by online. Social interaction is an important part of video game play (Przybylski, Rigby, & Ryan, 2010). Inkpen, Booth, Klawe and Upitis (1995) indicated that the level of motivation to continue playing the game was affected by the opportunity to play with a partner, and success in the game. Fromme (2003) stated that electronic game playing has integrated into children's social activities and the majority of sample children reported that they favoured playing electronic games with their friends.

- Alleviate boredom or pass the time: Some studies (e.g. Phillips, et al., 1995;

McFarlane, et al., 2002; Fromme, 2003; Lucus & Sherry, 2004) indicated that people played electronic games because they could help them pass the time or alleviate the boredom. For example, McFarlane et al. (2002) identified after they had surveyed sample UK schoolchildren:

> "There is a tendency among girls to play games when they are bored or have nothing more interesting to do, whereas boys are more likely to play games as a first choice activity." (p.24)

- Fantasy: Players can do things that they cannot do in real life such as driving racing car or flying (Lucas & Sherry, 2004). Players can imagine that they are completing the activity in a context in which they are really not present (Garris et al., 2002) but the authors also indicated that an engaging game should provide several fantasies so that different people can select fantasies that are personally appealing. The very interactive and graphic-rich games are increasing people's expectations and enhance the fantasy (Malone, 1981).

- Curiosity and mastery: If people can get unpredictable results from game play then they can be motivated to learn more skills (Malone, 1981). Curiosity and mastery encourages children to become engaged because children never know what is going to happen next when playing a game, therefore making them play on (Malone & Lepper, 1987). Children are not passively involved in games. They are actively seeking ways to master skills and solve problems. As argued by The British Educational Communications and Technology Agency (BECTA) (2001) "For many players the ultimate motivation is mastery – the promise that with enough energy and concentration you might ‘master the machine’, or at least the software” (as cited in Mitchell & Savill-Smith, p.18). Though the game should be novel and surprising, the games should be neither too simple nor totally incomprehensible (Garris et al., 2002). Games include “imaginary or fantasy context, themes, or characters” and provide “optimal level of informational complexity” which made games motivational (Garris et al., 2002, p.447).

There will be further consideration of game motivation, engagement and learning in section 2.2.

### 2.1.5 CHILDREN’S MOBILE PHONE USE

Mobile phones are very popular all over the world. Around ten years ago there were estimated to be 1.5 billion mobile phones in the world (Prensky, 2004) increasing to six billion by the end of 2011 (BBC, 2012). In the UK the mobile phone penetration rate of young people is high. Ofcom (2006) found that 49% of 8 to 11 year old children and 82% of 12 to 15 year old children owned a mobile phone. It was clear that there was a notable increase in mobile phone ownership levels between the ages of 8 to11 years and 12 to 15 years. It is reasonable to presume that this change is related to children moving from primary to secondary school and increasing independence.

The mobile phone has been so popular because of mobility, flexibility and availability. Ofcom (2006) found the top two reasons for having a mobile phone were because children want to keep in touch with friends or family. The most popular uses for children were sending text messages and making calls. The third most popular use was to use the phone for playing games. For children aged 8 to 11 years, girls were significantly more likely than boys to send text messages; and boys were significantly more likely than girls to use the phone to play games. Mobile phones were part of the daily culture of almost every child (Yerushalmy & Ben-Zaken, 2004).

There was some literature (e.g. Lubega, McCrindle, Williams, Armitage, & Clements, 2004; Inagaki, Kobayashi, & Nakagawa, 2004) which investigated young people's attitudes towards using mobile phones for learning. Lubega et al. (2004) conducted a survey in UK to investigate high-school students' attitudes towards mobile phones and learning and found that most students felt positive about using the mobile phone for communicating with classmates and teachers specifically for group work, discussion or getting help. Moreover, Inagaki et al. (2004) administered a questionnaire to find out primary children's attitudes about using mobile phones for learning in Japan. They found that children tended to use the mobile phone as a tool for learning and in addition used the phone to take pictures, send emails or use the video etc.

### 2.1.6 CROSS-CULTURAL STUDIES IN UK AND CHINA

A literature search was performed to try to find any cross-cultural studies about children's electronic game usage and preference at primary school level between UK and China from year 1990 onwards by searching the following electronic databases: SCOPUS and ProQuest. The search terms used were ("electronic games" OR "computer games" OR "video games" OR "digital games") AND ("game usage" OR "play time"

OR “game preference” OR “game attitude” OR “favourite game”) AND (“China” or “Chinese”). A total of 2 papers (Li & Wang, 2012; Lo & Lin, 2012) were returned by SCOPUS and no articles found by ProQuest. However, Li and Wang (2012) discussed the interrelation and the factors between undergraduates' interpersonal relationship and computer games. Lo and Lin (2012)’s study investigated second grade students' attitudes on the mathematics game Arithmetic Climbing. Neither of these papers involved a cross-cultural comparison.

Such terms were changed to (“electronic games” OR “computer games” OR “video games” OR “digital games”) AND “Cross-cultural” AND (“China” or “Chinese”). There were one article found by ProQuest and seven papers returned by Scopus. One article (Li & Kirkup, 2007) was found by these two databases. The researchers conducted a cross-cultural study in UK and China but the authors investigated the differences in use of, and attitudes toward the Internet. In addition, there was no cross-cultural study that investigated children’s attitudes towards electronic games in the other six papers. Therefore, the above literature search did not identify any previous cross-cultural study (involving UK and China) which investigated children’s attitudes towards electronic games.

## 2.2 GAME MOTIVATION, ENGAGEMENT AND LEARNING

Nowadays, children of all ages and adults are enjoying game playing. Researchers have found that students benefit from learning when they feel motivated about the learning activities (Malone & Lepper, 1987; Prensky, 2001; Garris, Ahlers, & Driskell, 2002;

Gee, 2003a, 2003b). For example, Gee (2003b) stated ‘Motivation is the most important factor that drives learning. When motivation dies, learning dies and playing stops’ (p.3). Therefore, a lot of researchers and games developers have begun to give attention to and study the educational value of computer games. They have proposed computer games as potential learning tools (e.g., Malone, 1981; Rieber, 1996; Prensky, 2001; Gee, 2003a; Squire, 2003; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005).

### 2.2.1 PLAY AND LEARNING

“Play” is a common word when speaking but it is a difficult term to define, and harder still to explain. The matter is not as simple as defining a word like “hand”. “What is play?” is a question that has attracted psychologists, biologists, educators, linguists, and anthropology researchers for decades starting in the late $18^{th}$ century. Dutch anthropologist John Huizinga (1955) suggested that play exists as an activity only for its own interest. He defined play as:

> “Play is a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tension, joy and the consciousness that it is ‘different’ from ‘ordinary life’” (p.28).

According to Huizinga, players know the consequences of play will not affect their lives outside the play, even if they are absorbed by the activity. Play can be deferred or suspended at any time. It is never imposed by physical necessity or moral duty. It is never a task. It is done at leisure, during "free time" (Huizinga, 1955, p.8). Kant (2008) agreed with Huizinga's view and argued that play is an enjoyable activity. He said:

> "Agreeable arts are those which have mere enjoyment for their objects. Such are all the charms that can gratify a dinner party: entertaining narrative, the art of starting the whole table in unrestrained and sprightly conversation, or with jest and laughter inducing a certain air of gaiety…In addition must be included play of every kind which is attended with no further interest than that of making the time pass by unheeded. " (Kant, 2008, p.98)

Kant (2008) claimed that play is agreeable on its own account, but labour work is disagreeable and is only attractive by means of what it results in (e.g., the pay). Based on the above illustrations it seems that people are engaged and motivated in a play activity because they want to do it and enjoy doing it.

> "Play is an intellectual activity engaged in for its own sake, with neither clearly recognizable functionalities nor immediate biological effects … and related to exploratory processes that follow the exposure of the player to novel stimuli" (Fabricatore, 2000, p.2).

So playing game is an enjoyable and spontaneous activity of young children. However, in addition to providing pleasure, play, especially during early childhood, has important roles in psychological, social and intellectual development (Reiber, 1996). Piaget (1951) stated that play is children's work. Piaget (1951) and Vygotsky (1978) share a common position that play is an important part of learning. According to Piaget (1951), children expand their knowledge and construct a sense of order and meaning of their world through playing. Fernie (1988) agreed with this view and stated that children improve their ability to communicate with their friends and adults by playing.

Prensky (2001) suggested that play put us in a relaxed, receptive frame of mind for learning because play is someone choosing to do pleasurable things. Though he stated that learning is hard work and we will need to use energy and make efforts to study, how can we make the learning fun? Prensky is a strong proponent of learning with game play: “We would build a fantastic game – one the target market couldn’t resist starting or put down once they began. The learning would happen almost without the learners realising it, in pursuit of beating the game. We would give them ‘stealth learning’” (Prensky, 2001, p. 24). He also indicated that electronic games were not the enemy but “the best opportunity we have to engage our kids in real learning” (Prensky, 2003, p.1).

Moreover, play makes learning more effective: “Adding fun into the process will not only make learning and training much more enjoyable and compelling, but also far more effective as well” (Prensky, 2001, p. 15). Gee (2007) also supports Prensky’s view that games are good for learning. So we should make an effort to create a positive learning environment and climate for children, to make them want to stay and be keen to learn (Purkey & Novak, 1996).

Tapscott (2005) showed that children will continue to play as long as they feel they are being challenged. When children were deeply engaged in hard and challenging activities, their learning was improved. Pivec and Kearney (2007) also found that children are motivated by games playing and desired learning outcomes will be achieved. So the following sections will discuss why games can increase engagement for learning.

### 2.2.2 GAMES AND ENGAGEMENT

Squire (2003) suggested that while playing a game, children are placed in a state of ‘flow’ (p.2). This is when the child is playing a game and the child is not aware of things going on around them. Flow theory (Csikszentmihalyi, 1990) examines this concept of engagement in more detail. The theory of flow has been widely discussed in recent research (Rieber, 1996; Prensky, 2001; Kirriemuir & Mcfarlane, 2004; Kiili, 2005). Cziksentmihalyi (1990) defines flow as “a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it”(p.4). Flow is a state of one who is completely absorbed or engaged in an activity. Prensky (2001) summarised the experience of flow as “in the flow state, the challenges presented and your ability to solve them are almost perfectly matched, and you often accomplished things that you didn’t think you could, along with a great deal of pleasure” (p.124). Prensky (2003) added that learning takes place throughout the game but children do not always realize that.

Flow theory proposed a number of different elements involved in achieving flow such as clear goals, immediate feedback, achievable challenges, no distraction, no worry of failure (Csikszentmihalyi, 1990). Firstly, flow experiences must have clearly established rules and goals. Students are more motivated if goals are defined clearly and the learning ultimately meets their needs and interests (Keller, 2010). Gee (2009) claimed that the rules of a game can be used to achieve goals which are personally and emotionally important to them. McClarty, Orr, Frey, Dolan, Vassileva, and McVay (2012) argued that games have the capacity to provide rewards by motivating children to continue practising and master skills by rewarding them by either giving them more time in the game or permitting the player to advance to higher levels. Secondly, flow requires focused concentration and immersion during game playing. It is important to “avoid distractions and disruptions that intervene and destroy the subjective experience” (Norman, 1993, p. 35).

Thirdly, children receive feedback and guidance as they perform tasks related to the activity goals such as how close the children are to achieving the goal. Through the feedback the player either succeeds in mastering something, or fails doing something, and has to try again or seek help to succeed in the end. The art of providing feedback in a game is extremely important and complex because ‘either too little or too much can lead quickly to frustration for the player’ (Prensky, 2001, p.122). Finally, to remain in flow, the complexity of the game task must increase in accordance with the player’s skills. When the challenge of a game is greater than the player’s skill ability, the player maybe put off from continuing to play it; when the skill is greater than the challenge, the player may feel bored or lack of fun. The TEEM (Teachers Evaluating Educational Multimedia) data also suggested that the degree of difficulty is an important facet if children are to enjoy playing. The game must be neither too difficult nor too hard (McFarlane et al., 2002). “In video games, losing is not losing, and the point is not winning easily or judging yourself a failure. In playing video games, hard is not bad and easy is not good" (Gee, 2003a, p. 165). So it is important to maintain a balance between challenge and the ability to encourage the player 'flow' in the game.

Jones (1998, table 1) indicated that the following game characteristics were essential to the design of engaging games drawing from Csikszentmihalyi's flow theory.

1. The game task can be completed
2. Ability to draw player in and concentrate on task
3. The game has clear goals
4. The game provides immediate feedback
5. Deep but effortless involvement (losing awareness of worry and frustration of everyday activity)
6. Completely in control of the game
7. Self-consciousness disappears during flow, but sense of self is stronger after flow activity
8. Sense of duration of time is altered.

Prensky (2001) also stated the key characteristics of an engaging game drawing upon the work of Malone (1981). Compared with the game characteristics in Jones (1998), Prensky (2001) added the elements of competition and cooperation in engaging games. Prensky also believed that a very careful balance between the graphics and visual appeal of the game and game control must be achieved in order for the game to be engaging. He stated that some games look very pretty, but the controls are difficult or the controls are very easy to use but there is no visual appeal. So a successful game should manage to achieve both (Prensky, 2001).

In addition, there were many studies which investigated the elements of an engaging game. For example, Amory, Naicker, Vincent, and Adams (1999) examined four different commercial games and found that game elements such as logic, memory, visualization and problem solving were most important game elements from students' questionnaire results. They claimed that students can be more motivated to play games with "objectives requiring higher order thinking skills, including visualization strategies that nurture creative problem solving and decision-making" (p.317). Whitebread (1997) also argued that children will learn better if the computer game is put into a real life situation. Miller and Robertson (2010) suggested that video games that stimulate the brain like "Big Brain Academy" can provide a context for learning. Kiili (2005) also stated some key elements of a good game such as having an engaging storyline or appropriate graphics and sounds.

Though there are well-documented studies that indicate the elements which can make games more engaging, we also should pay attention to the features of games that do not contribute toward engagement. Squire (2005) found that not all games appealed to every child in his study. The findings suggested that initially the children were not motivated straight away and questioned why they were playing a game. He addressed three factors that weaken players' motivations. These are:

- If students are forced to play a game or to learn specific content through playing games.
- If students find the games are difficult to master.
- If students are not able to see the relevance of game environments to their school curricula.

### 2.2.3 GAMES AND LEARNING

Benyon, Turner, and Turner (2005, p. 61) stated that: “engagement is concerned with all the qualities of an experience that really pull people in – whether this is a sense of immersion that one feels when reading a good book, or a challenge one feels when playing a good game, or the fascinating unfolding of a radio drama.”

The relationship between student engagement and student achievement has been studied for a long time. Dewey (1938) believed that teachers should create learning environments that are relevant and meaningful to students to help children’s learning. Brewster and Fager (2000, p.2) agreed with this opinion and stated that: “high motivation and engagement in learning have consistently been linked to reduced dropout rates and increased levels of student success”. Eccles and Wigfield (2002) also stated that a ‘highly motivated’ student studied hard whereas other students who were ‘lowly motivated’ may not study hard. So motivation and engagement are essential to achieve successful learning (Ainley, 2004). It is argued that electronic games can result in intense engagement with learners and the characteristics (e.g. challenge, curiosity, fantasy, and control) of computer games are likely to engage learners and contribute to learning (Rieber, 1996).

Ryan and Patrick (2001) found that children who are engaged are less likely to be disruptive in classroom situations. In their study they also suggested that if a child was disengaged from education, then high levels of disruption may be seen. Ryan and Patrick (2001) suggested that boredom was one of the reasons why children disengage in class. Prensky (2005) added to the above and identified that children have short attention spans in classrooms but they did not have short attention spans when using computer games.

Okan (2003) also believed that students who were highly motivated through rich and engaging experiences were able to enhance their understanding of the subject taught. He clarified this view by suggesting this is mainly because "children cannot help but pay attention to information that is presented in dynamic and memorable ways" (Okan, 2003, p.258).

There are many examples in which computer games have been used to support learning and teaching involving school children in recent years. For example, recent research with school children includes developing a collaborative mathematics game for children (Klawe, 1999); the use of commercial off-the-shelf computer games for teaching in formal education (Sandford, Ulicsak, Facer, & Rudd, 2006); off-the-shelf historical games (Squire & Barab, 2004); multi-user gaming environments (Barab et al., 2005); and game-console Nintendo DS "Brain Training" programme (Miller & Robertson, 2010).

## 2.3 MATHEMATICS LEARNING

This section provides an overview of why mathematics learning is important in general. Then literatures related to numeracy skills including the importance of mental computation are discussed. Finally, there will be a discussion about mathematics attitudes and the importance of mathematics attitudes for mathematics learning.

### 2.3.1 THE ROLE OF MATHEMATICS

Mathematics plays an important role in our lives (Cockcroft, 1982; Clemson & Clemson, 1997; Burr, 2008). Shopping or cooking is an example of where mathematical knowledge can be used in daily life, because calculations, measurements or estimations are used. Mathematics is required throughout the world in many jobs, such as science, engineering, medicine, business management and many areas of Information and Communications Technology. Professor Doug Arnold (2003) answered the question "What makes the math sciences so central?" in his May 2003 commencement address for the mathematics and statistics graduation at the University of Illinois in Urbana-Champaign by quoting Galileo: "The great book of nature can be read only by those who know the language in which it was written. And that language is mathematics.", and adding "Math is the way to understand all sorts of things in the world around us" (no page).

Charles and Lester (1982) stressed the importance of mathematics because mathematics can provide students with basic life skills and the ability to be “productive members of society” (p.3). They also suggested that mathematics is related to many careers. The Scottish Curriculum for Excellence stated that mathematics helps children to understand the world and helps them obtain success in future jobs, leisure activities and as citizens (Scottish Executive, 2004). Smith (2004) also stated that “problems with basic mathematics skills have a continuing adverse effect on people's lives" (p.13) and those problems involving numeracy lead to the 'greatest disadvantages' for their later jobs (p.13). He suggested that people "with limited basic mathematical skills are less likely to be employed, and if they are employed are less likely to have been promoted or to have received further training" (p.13). So in order to "face the challenges of the 21st century, each young person needs to have confidence in using mathematical skills, and Scotland needs both specialist mathematicians and a highly numerate population" (Scottish Executive, 2006, p.18).

The Scottish Government (n.d., p.1) listed the outcomes of learning mathematics. Learning through mathematics enables children and young people to:

- "Develop a secure understanding of the concepts, principles and processes of mathematics and apply these in different contexts, including the world of work
- Engage with more abstract mathematical concepts and develop important new kinds of thinking
- Have a understanding of the application of mathematics, its impact on our society past and present, and its potential for the future
- Develop essential numeracy skills, including arithmetical skills, which allow them to participate fully in society
- Establish firm foundations for further specialist learning, including for those who will be the mathematicians of the future
- Have a understanding that successful independent living requires financial awareness, effective money management, using schedules and other related skills

- Interpret numerical information appropriately and use it to draw conclusions, assess risk, and make reasoned evaluations and informed decisions
- Apply skills and understanding creatively and logically to solve problems, within a variety of contexts
- Appreciate how the imaginative and effective use of technologies can enhance the development of skills and concepts."

Because mathematics is so important in our daily lives, many countries list mathematics as a main subject in primary and secondary school. Mathematics is "regarded by most people as being essential" to learn (Cockcroft, 1982, p.1). "All teachers have responsibility for promoting the development of numeracy. With an increased emphasis upon numeracy for all young people, teachers will need to plan to revisit and consolidate numeracy skills throughout schooling." (Scottish Executive, 2006, p. 20)

Numeracy is a part of mathematics and plays a key part in our lives in the form of time management, money management as well as being a part of our recreational activities. Also there will be some agreement on the areas of numeracy that are useful in other subjects. For example, a geography teacher may be able to teach about real data such as longitude or latitude, or a PE teacher could use timing in athletics. The next section will discuss the literature related to numeracy learning.

### 2.3.2 NUMERACY LEARNING

The British National Numeracy Project of Department for Education and Employment (cited in Dillon & Maguire, 2011) defined numeracy as:
"more than knowing about number and number operations. It includes an ability and an inclination to solve numerical problems, including those involving money or measures. It also demands familiarity with the ways in which numerical information is gathered by counting and measuring and is presented in graphs, charts and tables" (p.295).

Numeracy is a subset of mathematics which can be permeated to all areas of learning and allow pupils the opportunity to access the wider curriculum (Scottish Government, 2009). "All teachers have responsibility for promoting the development of numeracy. With an increased emphasis upon numeracy for all young people, teachers will need to plan to revisit and consolidate numeracy skills throughout schooling." (Scottish Executive, 2006, p.20) Therefore it is essential that all teachers need to develop and reinforce numeracy skills within their own teaching activities and studies.

Numeracy learning is important in everyday life. "Being numerate helps us to function responsibly in everyday life and contribute effectively to society. It increases our opportunities within the world of work and establishes foundations which can be built upon through lifelong learning" (Scottish Government, 2009, p.37). Like all learning, numeracy learning begins in the home and continues in nursery with, for example, counting, songs and rhythms. As children move to school they use numeracy (e.g. computation, measurement or estimation) in a wide range of everyday activities at school and in activities out or within school, and at play. Numeracy learning enables a young person to understand scientific concepts, interpret figures, be proficient with money, learn time management skills etc. Numeracy skills help children become confident with solving problems, accessing and interpreting information, weighing up different options, analysing situations and hence making responsible decisions (Scottish Government, 2009). Having well-developed numeracy skills also allow young people enhanced enjoyment in a large number of leisure activities (Scottish Government, 2009).

So young people need to develop essential numeracy skills which will provide them with the knowledge, concepts and skills required for life-long learning and enable them to be successful in their everyday lives at school and in their life at work. Curriculum for Excellence recognises the importance of numeracy in learning and in life and promotes numeracy across all areas of the curriculum, ensuring that children develop the necessary skills and the confidence to apply numeracy skills throughout their learning (Scottish Government, 2011).

Though numeracy learning is being emphasized, the report for the Confederation of British Industry (CBI) said school-leavers and even graduates lack basic numeracy skills. According to a survey of senior executives at 694 companies, almost two-thirds of employers said that standards of numeracy should be tackled (Woolcock, 2010). So like the official report Curriculum for Excellence Factfile stressed: “All schools and educational establishments need to have strategies in place to ensure that children and young people develop high levels of numeracy skills” (Scottish Government, 2011, p. 1).

### 2.3.3 MENTAL CALCULATION

Cockcroft (1982) commented: “In almost all jobs the ability to carry out some calculations mentally is of value and lack of ability to do this is a frequent cause of complaint by employers” (p.20). In the past, primary mathematics computation in early school years was based on the pen-and-paper algorithm (Cooper, Heirdsfield, & Irons, 1996). Cockcroft (1982) claimed that mental computation was no longer emphasised in classrooms, expressing concern at the decline in attention given to skills associated with mentally calculating sums. Similar views were expressed by Reys (1984) who clearly stated that ‘‘mental computation should be a visible part of an elementary mathematics program’’ (p.550). Now, different official reports (Scottish Executive, 2006; Scottish Government, 2009, 2011; HMIe, 2010) have placed an emphasis on mental calculation. More teachers now give more opportunities for children to develop efficient and flexible mental calculation (HMIe, 2010). The report by the United Kingdom’s Numeracy Task Force (cited in Stephens, 2000) stated that the importance of mental calculation in relation to the use of calculators supported the UK National Numeracy Strategy approach “Calculators are best used in primary schools in the later years of Key Learning Stage 3, and should not be used as a prop for simple arithmetic. Teachers should teach pupils how to use them constructively and efficiently.” (p.23)

Mental calculation is defined as “the process of carrying out arithmetical operations without the aid of external devices” (Sowder, 1988, p.182). Mental calculation is the thinking and calculation which would be done ‘in the head’ rather than ‘on paper’ (Maclellan, 2001). One simple reason to emphasize mental mathematics is that it is useful for us. For example, people commonly estimate or calculate mentally the cost of a shopping cart of groceries, pay tips, discounts of clothes, the time needed to travel certain distances, and others. Bell (1974) noted that in daily life, adults use estimation more often than exact computation. The finding is supported by Northcote and McIntosh (1999). It was found that adults in their everyday lives use mental computation for over three quarters of all their calculations. The Northcote and McIntosh (1999) survey, conducted with two hundred adults over a twenty-four-hour period, found that only 11.1% of all calculations involve a written component. It seems reasonable to argue that we need to spend school time on mental computation because it may be the calculation method most needed in adult life.

Maclellan (2001) recognized the importance of including mental computation in the mathematics curriculum that promotes number sense. She pointed out the most important difference between written calculation and mental calculation is that the use of written algorithms encourages children to follow different steps without thinking about what they are doing but mental computation allows them to determine what the numbers in the problem mean. Mental arithmetic was an important skill in daily life, not only mental work developing insight into the number system but also promoting success in later written calculations (Thompson, 1999)

Therefore, because researchers and practitioners have identified the value of mathematics for all, it is important that we consider how to help students perform better in mathematics, especially for mental calculation. As Volet (1997, p.235) points out, “there is growing evidence that individual differences in academic performance cannot be explained as solely the result of differences in general ability but appears as the product of complex and dynamic interactions between cognitive, affective and motivational variables. " Neale (1969, p.631) noted that "something called 'attitude' plays a crucial role in learning mathematics". The following section will deal with the literature related to students' attitudes to learning mathematics.

## 2.3.4 ATTITUDES TOWARDS MATHEMATICS

In this section definitions of attitudes and why attitudes are important will be described. Then the area of attitudes towards mathematics and the relationship between mathematics attitudes and achievement will be discussed. Finally teacher factors that influence attitudes towards mathematics will be addressed within this section.

### 2.3.4.1 Definition of Attitudes

Krech (1960) defined attitudes as "an enduring system of positive or negative evaluation, emotional feeling and pro or con action tendencies, with respect to a social object" (p.177). Eagly and Chaiken (1993) defined attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour" (p. 1). Although formal definitions of attitudes vary, in the above these studies attitudes are generally described as a predisposition to respond to a certain object either in a positive or in a negative way.

Krech (1960) emphasized three essential components of attitudes: the cognitive component, the affective or feeling component and behavioural component. More recently, Zimbardo and Leippe (1991), and Aiken (2002) defined attitude in a similar way to Krech. They suggest that attitudes are comprised of three constructs: cognitive - belief, affective - feeling, and a behavioural component - action.

The cognitive component of attitudes consists of beliefs or thoughts about a certain object. For example, "A belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (Neale, 1969, p.632). Cognitive components of attitudes are considered to be fundamental and sustained over time, and are also closely connected to basic values and beliefs (Pendleton, Schofield, Tate, & Havelock, 2003). The affective component of attitudes is the "feeling" or mood of liking or disliking the attitude object. Affective responses "involve positive or negative feelings of moderate intensity and reasonable stability" (McLeod, 1992, p.581). Affective attitudes reflect emotional responses and personal experience, and they are more influenced by personal feelings and context (Wood, 2000). The behavioural component of attitudes is "a state of a person that predisposes a favorable or unfavorable response to an object, person, or idea" (Triandis, 1991 p. 485). Behavioural response is what an individual actually does or intends to do (Al-Khaldi & Al-Jabri, 1998). It is action with a tendency to engage in or avoid a certain activity. Therefore, attitudes consisted of beliefs (cognitive), feelings (affective) and plans to do (behavioural).

Eagly and Chaiken (1993, p.167) stated that "response to an inquiry about an attitude toward a specific behaviour directed toward a given target in a given context at a given time should predict the specific behaviour quite well because this attitude exactly corresponds to the specific behaviour". There is a relationship between a person's knowledge or feelings towards some person or object and their actual reactions. For example, a student's attitude toward mathematics includes the students' beliefs about mathematics, what the student's feelings toward mathematics are (liking or disliking of mathematics) and this information may help to predict whether the student will engage in any further study in mathematics or not. Attitudes play a major role in determining behaviour.

### 2.3.4.2 Attitudes towards Mathematics

This section describes studies in relation to negative attitudes towards mathematics and tries to find out why children have negative mathematics attitudes. The section also discusses the relationship between attitudes towards mathematics and mathematics achievement.

#### 2.3.4.2.1 Negative attitudes towards mathematics

"People frequently respond to the word 'mathematics' in particularly negative ways" (Ollerton, 2004, p.13). Burr (2008, p.48) found that the name of training courses such as "numeracy" or "basic mathematics" may put people off and suggested alternatives included "managing money better", "organising your time" and "mathematics in your home". People in the study thought that mathematics was difficult subject and "scared of numeracy" (Burr, 2008, p.31). A UK government survey in 2008 estimated that only ten percent of adults with poor GCSE grades in mathematics gained qualifications in numeracy during a further training program (Burr, 2008).

Attitudes towards mathematics in adults can be traced to their childhood (Morrisett & Vinsonhaler, 1965). There is evidence that very definite attitudes towards mathematics may be formed as early as the third grade (Stright, 1960). But many studies suggested that students' mathematics attitudes changed according to their progress through school (Kloosterman & Cougan, 1994; Ma & Kishor, 1997; Utsumi & Mendes, 2000). Kloosterman and Cougan (1994) conducted a qualitative study of 62 students from first grade to sixth; seven out of ten first grade pupils were very positive towards mathematics and about half of the second grade pupils expressed strong liking of mathematics. However, by third grade "low achievers were developing distaste for the subject" (Kloosterman & Cougan, 1994, p. 382).

One possible explanation for this is that younger students felt successful because they began to do the things which they were not able to do before. This generates positive effects on their mathematics attitude (Kloosterman & Gorman, 1990). But mathematics is a difficult subject to understand (Clemson & Clemson, 1997). People are required to overcome some difficulties during the process of learning mathematics. If a learner faces a difficulty, this may lead the person to block the process of learning and then have negative attitudes towards mathematics. The learner may not try to conquer the problems because they think they will not succeed (Ollerton, 2004). A high level of negative attitudes towards mathematics is associated with a lower level of achievement (Quilter & Harper, 1988).

2.3.4.2.2 Relationship between Mathematics Attitudes and Mathematics Achievement

Aiken (1970) provided a comprehensive review of literature about mathematics attitudes and achievement in mathematics. He stated that the relationship between attitudes toward mathematics and achievement in mathematics was not consistent. Overall there was a positive, but small to moderate correlation, between attitudes and achievement. Aiken's findings paralleled that of Neale (1969): "When attitude scores are used as predictors of achievement in mathematics, a low but significant positive correlation is usually found" (p. 295). Suydam and Weaver (1975, p.45) illustrated that children can perform better if they have a positive attitudes towards mathematics: "Teachers and other mathematics educators generally believe that children learn more effectively when they are interested in what they learn and that they will achieve better in mathematics if they like mathematics. Therefore, continual attention should be directed towards creating, developing, maintaining and reinforcing positive attitudes." Begle (1979) also supported this view and showed that students who have a positive attitude towards mathematics tend to do well in the subject, and students tend to do badly if they have negative attitude. Attitude is one of the stumbling blocks for progress in learning mathematics (Aiken, 1976).

Since the 1980's, the literature on attitudes toward mathematics and achievement in mathematics has grown exponentially. Unfortunately, the studies do not provide consistent findings regarding the relationship between attitude and achievement in mathematics (Ma & Kishor, 1997). For example, some studies found no significant relationship between attitudes towards mathematics and achievement in mathematics (e.g. Quinn & Jadav, 1987; Ma & Xu, 2004). Others found a statistically significant but weak positive effect (e.g. Aiken, 1970; Wolf & Blixt, 1981; Minato & Kamada, 1996; Ma & Kishor, 1997). Others found a positive effect (e.g. Suydam & Weaver, 1975; Begle, 1979; White, 2001; Singh, Granville, & Dika, 2002).

Ma and Kishor (1997) offered some explanation for these different findings. This relationship was found to be dependent on a number of variables which included the ethnic background, sample selection, variability with sample size, ability, and the date of publication. Aiken (1970) also proposed why there are low correlations between attitude and achievement at the early elementary grade and upper elementary grades. This may be because attitude tends to be unstable in the early elementary grades and students may not be able to express their attitudes reliably, and it varied with level of maturity. Moreover, often studies used or developed their own instruments to gauge the attitudes toward mathematics (Duatepe-Paksu & Ubuz, 2007). All these may be factors in the difference in findings.

Studies conducted at the elementary school level appear to indicate that the relationship between attitude and achievement has been positive (Aiken, 1976). Wolf and Blixt (1981) found that grade four through to seven were “perhaps the most important for the development of attitudes toward mathematics” (p.832). They used a quasi-experimental design to investigate 2,429 students from grade one to grade eight and found the largest correlations (.16 to .23) between mathematics attitudes and mathematics achievement in grade four to seven. This result provided some support for the assertion from Aiken (1970). He noted that the correlations between attitude and achievement in elementary school are statistically significant in certain instances. The late elementary and early junior high school grades are perhaps the most important for the development of attitudes toward mathematics (Aiken, 1976). In addition, Ma and Kishor (1997) summarized their findings about the relationship between attitude towards mathematics and achievement in mathematics from 113 survey studies and found the relationship between attitudes towards mathematics and achievement in mathematics was positive and reliable, but not strong. They showed that the relationship between attitude and achievement is strengthened by 367% from the lower elementary grade (1 to 4) to the upper elementary grade (5 and 6) and 79% from the upper elementary grades to the junior high grades and a decrease of 20% in the strength of the relationship between attitude and achievement from junior high grades to senior high grade. It seems to strengthen the previously noted points that the elementary school level is important for students as it may be experiences at this stage that shape their mathematics attitudes. Liebeck (1990) suggested that if we can keep children's attitudes towards mathematics positive throughout their primary schooling, the pain of learning any further mathematics may be reduced. The study of Di Martino and Zan (2011) even suggests that it is never too late to change students' attitude towards mathematics. Developing more positive attitudes to mathematics may encourage people to learn mathematics. "Positive attitude toward mathematics is thought to play an important role in causing students to learn mathematics." (Neale, 1969, p.631)

Therefore, learning more about attitudes towards mathematics in primary schooling and researching the relationship between mathematics attitudes and mathematics performance is still important.

2.3.4.2.3 The teacher's influence on attitudes towards mathematics

Teachers' attitudes are viewed as being of particular importance (Aiken, 1976). "Most important from the standpoint of potential influence on students' attitudes toward mathematics are investigations of the classroom behaviour and techniques employed by teachers" (Aiken, 1976, p. 303). It was therefore suggested that pupils' attitudes towards mathematics are related to the quality of the teaching (Haladyna, Shaughnessy, & Shaughnessy, 1983).

Haladyna et al. (1983) used quantitative methods to determine that there was a strong relationship between various components of teacher quality such as teacher's enthusiasm, respect, commitment to help students learn etc. and students' mathematics attitudes for students in grades four, seven, and nine. Supportive teachers were found to positively influence students' value of mathematics and unsupportive teachers had a negative influence on students' value of mathematics (Midgley, Feldlaufer, & Eccles, 1989).

This view is supported by later research literature. The teachers' methods of mathematics teaching accounted for the students' positive or negative feelings towards mathematics (e.g. Griffiths, 2005; Bolaji, 2005; Yara, 2009). Nowadays, teachers often tend to teach mathematics through the methods that they experienced at school (Griffiths, 2005). Mathematics is taught as

> "children sitting behind a desk, and the teacher at front coaxing out information giving examples of how to do specific calculations, then provide

questions on a worksheet or an exercise from a textbook" (Ollerton, 2004, p.57).

Harries and Sutherland (1999) stated that primary mathematics is predominantly learnt by pupils working from textbooks. Ollerton (2002) found that many exercises in textbooks were boring for both teachers and children. Hedges and Cullen (2005) believes that the learning should emerge from the children's interests, but textbooks do not use children's interest, as the authors cannot know their interest (Tucker, 2005). Consequently, children may become uninterested and find it hard to engage with the task on the textbook.

Clemson and Clemson (1997) stated that if children do not experience interesting methods, it is no wonder that negative views are produced. Sedighian (1997) states that the difficulty in helping students learn mathematics is in how to motivate them to want to spend time and to engage in mathematical activities, and how to aid them cognitively to construct mathematical knowledge.

Cattell and Butcher (1968) found that motivational factors have high correlations with achievement. Aiken (1970) and McLeod (1992) further stated that it is important to investigate the entire domain of affective and cognitive variables relative to mathematics learning. Sedighian and Sedighian (1996) proposed that in order to motivate children to do mathematics one must understand their needs. As Gardner (1975, p. xii) wrote in his Mathematical Carnival:

> "The best way, it has always seemed to me, to make mathematics interesting to students … is to approach it in a spirit of play. … No student is motivated to learn advanced group theory, for example, by telling him that he will find it beautiful and stimulating, or even useful, if he becomes a particle physicist. Surely the best way to wake up a student is to present him with an intriguing mathematical game, puzzle, magic trick, paradox, limerick or any score of things that dull teachers tend to avoid because they seem frivolous." (Gardner, 1975, p. xii)

So it is important for teachers to use different methods to make motivating and attractive mathematics lessons and make children's feeling towards mathematics more positive.

### 2.3.5 GAMES IN THE CLASSROOM

It has been fashionable to use computer games in teaching in recent years. Williamson (2009) conducted a survey of over 1600 United Kingdom teachers and found that 35% of teachers have already used computer games in their teaching and 60% of them would consider using computer games in the future. In the United States, Project Tomorrow (2008) did a survey where over 25,000 teachers participated. Project Tomorrow found that 11% of teachers have already used games in their classroom, 65% of teachers are interested in using games in the classroom and over half of them would like to learn more about integrating games in their teaching strategies.

The most common reasons of teachers for considering using games in the classroom were motivation and engagement (Williamson, 2009). In the survey study of Williamson (2009) the majority of teachers believed that playing computer games could lead to improved children's skills and knowledge. For example, 85% felt that game playing helped support children's cognitive development, and over 65% teachers thought that playing games could develop their ICT development, and also their logical thinking, planning or strategizing. He found that the vast majority of teachers have previous experience in using games in school and the most popular gaming console used in schools is the handheld Nintendo DS (8% of teachers who have gaming experience in school have used such a device). This suggested that affordability and portability are emerging considerations by teachers (Williamson, 2009).

Though many teachers are interested in using games for learning, teachers still perceive several barriers to using games in the classroom. For example, Davis and Pettitt (1994) stated that children will ignore the teacher when they are playing games. From the survey conducted by Kirriemuir and McFarlane (2003), teachers identified the following obstacles to incorporating games in classroom learning activity: verifying which game or game components are suitable for learning purposes; finding adequate time during the class period for supporting children's learning by games; finding support materials for teachers' needs to guide them in using games in the classroom; license agreements make it difficult to introduce some games in school; and existing classroom computers may not support games technology. The study by Williamson (2009) also identified teachers' concerns which included: the high cost of computer hardware and software licensing, the lack of knowledge of how to use games for education and the fact that students might not be able to associate the games with learning.

In all, the literature has presented two aspects of teachers' attitudes towards using games in the classroom. Many teachers are interested in and intrigued by the prospect of using gaming in the classroom and an affordable and portable game is popular for teachers to use in classrooms – but there are also some hindrances that prevent teachers from using games in classrooms.

## 2.4 EMPIRICAL STUDIES OF USING ELECTRONIC GAMES FOR MATHEMATICS LEARNING

Although some of the literature discussed in the section above is based on empirical studies, much of it is based on opinions. The purpose of this section is to provide a literature review about empirical research conducted on the effects of using electronic games for learning. This section summarises findings from previous literature review and research studies which have investigated the outcome of using electronic games on primary children's mathematics learning by using different games and different methods. The major issues emerging for further research in the field of game based learning will be discussed and the results will help to guide the study for this thesis and form major variables for the study.

### 2.4.1 THE FINDINGS OF PREVIOUS SYSTEMATIC LITERATURE REVIEWS

Before conducting the review, I tried to find other previous literature reviews which had been undertaken associated with the evidence on use of electronic games for learning purposes. Seven literature reviews were identified but the articles by Emes (1997) and Harris (2001) were excluded from consideration because the number of studies included within these two papers was very small: Emes (1997) reviewed three studies and Harris (2001) reviewed two studies only. However, it should be noted that these two articles found that there was no effect on academic achievement by using computer games. So the following section summarises the results of five review articles of empirical studies (see Table 2.1).

Table 2.1: Reviews of empirical studies investigating the effectiveness of electronic games

| Article | No. of studies | Results |
|---|---|---|
| Randel, Morris, Wetzel & Whitehill (1992) | 68 | Mixed |
| Dempsey, Lucassen & Rasmussen (1996) | 99 | Positive |
| Hays (2005) | 48 | Mixed |
| Vogel, Vogel, Cannon-Bowers, Bowers, Muse, & Wright (2006a) | 32 | Positive |
| Ke (2009) | 65 | Mixed |

In an early review of the evidence, Randel, Morris, Wetzel and Whitehill (1992) compared the instructional effectiveness of games with conventional classroom instruction in their meta-analysis of 68 gaming studies. These studies covered a period of 28 years from 1963 to 1991. Thirty-eight studies reported no difference between games and conventional instruction, 22 reported students using games outperformed their classmates in the conventional instruction group, 3 studies favoured conventional instruction and 5 studies favoured games but their controls were questionable. Though the results showed that more than half the articles showed no link between gaming and attainment, Randel, et al.(1992) stated that if the learner knew what to do and the purpose of playing, the beneficial effects of games were most likely to be found. But they also specifically stated some limitations of the articles; for example there was insufficient detail about the interventions or the demographic details, the absence of control groups and lack of statistical data.

Dempsey, Lucassen and Rasmussen (1996) reviewed 99 papers related to using instructional games for learning. They separated games into simulations, puzzles, adventures, experimental games, motivational games, modeling, and others (e.g., frame games) and found simulation games were used for the largest number of articles. They also found that games served many functions such as “tutoring, amusing, helping to explore new skills, promoting self-esteem, practicing existing skills, drilling existing skills, automatizing, and seeking to change an attitude” (p.8). The games in most articles were used to practise existing skills and learn new skills. In terms of learning outcomes, they found most games intended to promote “higher-level intellectual skills and attitudes learning” (p.7).

Another review, based on 48 empirical research articles on the effectiveness of instructional games by Hays (2005), found that “there is no evidence to indicate that games are the preferred instructional method in all situations" and "although some games can provide effective learning for a variety of learning for several different tasks (e.g., math, attitudes, electronics, and economics), this does not tell us whether to use a game for our specific instructional task" (p.6).

Vogel, et al. (2006a) conducted a quantitative meta-analysis with 32 studies on computer games and interactive simulation. They reported that interventions using interactive simulations or games (or both) tended to result in higher cognitive gains and better attitudes towards learning compared with using traditional teaching methods. However, they commented that "the research base was insufficient to draw conclusions with much confidence" (p. 238).

More recently, Ke (2009) analysed 65 research studies that examined the effectives of computer-based games on learning and found the results were mixed with 34 out of the 65 studies reporting significant positive effects, 17 articles reporting mixed results, 12 reporting no difference between computer games and conventional instructions and one study finding that conventional instruction was more effective compared with computer games. She also stated that games may not be the most effective tool for all content and in all situations.

From the above literature reviews, it appears that there are no consistent conclusions that can be drawn from the studies and no evidence to show that games can provide effective learning in all situations. A possible reason is because gaming researchers have used 'different configurations of games such as networking or being competitive'

(Ke & Grabowski, 2007, p.250), or different methodology (quantitative design, qualitative design or mixed method design), or examined different outcomes such as exam performance or learning attitudes, or used different conventional instructions. So it is difficult for researchers to determine the true relationship between gaming and interactive simulations with learning (Vogel, et al., 2006a).

It was found that these reviews examined empirical studies in a wide variety of subjects (e.g., mathematics, language learning, geography, physics, military, health, science) with different age groups (primary school students, middle school students, university/college students, and adult learners). None of the reviews focused exclusively on empirical studies in mathematics in primary school settings. However, all literature reviews had included some papers reporting using games for mathematics learning and mathematics was the subject area with the greatest percentage of generating positive results (Ke, 2009; Vogel, et al., 2006a; Hays, 2005; Dempsey et al., 1996; Randel et al., 1992). However the results of literature reviews indicated that empirical studies on mathematics games in the primary setting were far fewer. For example, Hays (2005) found 48 provided empirical data on effectiveness of games. Only eleven focused on primary school settings, and only 4 articles considered the learning effect of mathematics instructional games in the primary school. Furthermore, there were only 7 studies aimed at gaming effect on primary students' mathematics learning from 65 articles in Ke (2009)'s review. Moreover, there was no study which was conducted on using mobile phone games in the above literature reviews.

Following on from this, it was necessary to look specifically for individual papers which reported empirical studies on the effectiveness of using games on different platforms for mathematics learning in a primary school setting. One reason for this is that the studies by Randel et al. (1992) and Dempsey et al. (1996) are now almost 20 years old. With the development of technology, digital natives have become comfortable with using different tools and surroundings to achieve learning outcomes (Prensky, 2001). Therefore, it is appropriate to focus on the most current literature available to identify results for generalization. So the current literature reviewed below included articles which were written in English only from 2000 to 2011. Any studies written in another language were not included.

### 2.4.2 LITERATURE REVIEW ON GAME BASED LEARNING FOR MATHEMATICS IN PRIMARY SCHOOL

Before conducting the literature search, the papers presented in the literature review of Ke (2009), Vogel, et al. (2006a) and Hays (2005) focusing on those papers that were published after year 2000 which reported findings from studies using electronic game for mathematics learning in primary school will be included in the review. After removing duplicates, five papers (Ota & DuPaul, 2002; Laffey, Espinosa, Moore & Lodree, 2003; Rosas, Nussbaum, Cumsille, Marianov, Correa, Flores, Grau, Lagos, Lopez, Lopez, Rodriguez & Salinas, 2003; Vogel, Greenwood-Ericksen, Cannon-Bowers & Bowers, 2006b; Ke & Grabowski, 2007) were identified as focusing on the use of electronic games for mathematics learning in primary school. There was one study by Rowe (2001), presented in the review of Hays (2005), that investigated using mathematics games to help teach fractions, decimals and percentages in an elementary school classroom. But the mathematics games used in this study were two non-electronic card games. Though this study was not included in the following literature review, the results indicated that card games can improve learners' mathematics performance, but the effectiveness of a game depended on the game characteristics and how it was used.

When conducting the literature search, the keywords of "Game based learning" yielded over 30000 results (See Table 2.2) when searching the databases of ASSIA Applied Social Sciences Index and Abstracts (CSA), Australian Education Index (Dialog), British Education Index (Dialog), ERIC (CSA), SCOPUS and University of Dundee Library catalogue available from CrossSearch of University of Dundee Library.

Table 2.2: CrossSearch Results from Dundee university library

**Results by Databases**

Search for **"game based learning"** found **35165** results

| Database Name | Status | Hits |
|---|---|---|
| SCOPUS | DONE | 33444 |
| University of Dundee Library catalogue | DONE | 3 |
| ASSIA Applied Social Sciences Index and Abstracts (CSA) (ProQuest XML) | DONE | 42 |
| British Education Index (Dialog) (ProQuest XML) | DONE | 69 |
| Australian Education Index (Dialog) (ProQuest XML) | DONE | 178 |
| ERIC (CSA) (ProQuest XML) | DONE | 1429 |
| **Combined Results** | **First 152 records** | **35165** |

Because ninety-five percent of these results were from Scopus database, the literature search was undertaken in the SCOPUS database.

The search terms used were "game based learning" or "game based learning AND classroom" or "game based learning AND school AND student" or "game based learning AND education" or "game based learning AND mobile phone".

Table 2.3: Keyword Search 1x 1 Matrix

| Keywords | Game based learning | education | Classroom | School and Student | Mobile phone |
|---|---|---|---|---|---|
| Game based learning | 3411 | 220 | 42 | 55 | 56 |

As is seen in Table 2.3, the keywords of “game based learning” and publication year after 1999 produced 3411 articles when searching Scopus host database. However, when including the terms “game based learning” and “education”, the search total produced 220 articles.

If I changed the search criteria to limit the subject area to “mathematics”, 220 articles were reduced to 41. But of these 41 articles, there were 39 sources from Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). One article was from Journal of Universal Computer Science and one from Wseas Transactions on Information Science and Applications. All these 41 articles were technical. So limiting the search criteria to subject area “mathematics” was not suitable. I then excluded the subject area “computer science” because these articles were of a technical nature. This reduced the numbers of identified articles to 53 for review.

It also can be seen from Table 2.3 that when examining “game based learning” AND “classroom”, the results produced 42 articles for review. Using the keywords of “game based learning” AND “school” AND “student” produced 55 hits. Inputting the keywords of “game based learning” AND “mobile phone” produced 56 hits. So there were a total 206 papers for review. Because this study focused on the outcomes and effects of using electronic games with primary school students for mathematics learning, the articles located through the database searches that did not fall within that focus were excluded from consideration. For instance, there were articles focusing on higher education (Yip & Kwan, 2006) or focusing on nursery children (Rasanen, Salminen, Wilson, Aunio, & Dehaene, 2009), articles addressing games for learning geography (Tuzun, Yilmaz-Soylu, Karakus, Inal, & kizilkaya, 2009), learning English (Yu, Chang, Liu & Chan, 2002) or learning computer science (Papastergiou, 2009). After analysing all the results of the searching, I identified 21 papers classified in Table 2.4 after removing duplicates and including seven applicable referenced citations from related papers and five from a game literature review paper. It was a good way to find important papers by checking the references of related papers and the game literature review papers. For example, the article Moreno (2002) was cited in the paper Ke and Grabowski (2007) or the papers Shin, Norri and Soloway (2006) and Fuchs, Fuchs, Hamlet, Powell, Capizzi and Seethaler (2006) were cited in the paper Rasanen, Salminen, Wilson, Aunio and Dehaene (2009) though the paper by Rasanen, et al. (2009) was excluded from consideration because they studied with kindergarten children. All these articles reported experimental studies which used electronic games for mathematics learning in primary school setting.

The total number of reviewed papers was 21 (see Table 2.4), nine of which were conducted in the US, two in Turkey, two in the UK and two in Singapore. These four countries represent 70% of studies covered in this review. The other countries where research was conducted were Chile, South Africa, Taiwan, Australia, Philippines and Sweden (see Figure 2.2).

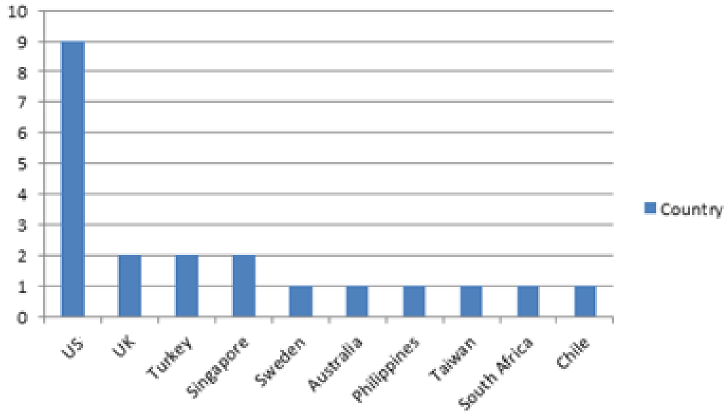


Figure 2.2: The countries where research was conducted in this review

The countries represented in this literature review were drawn from the continents of America, Europe, Australia, Asia and Africa. These data suggest that the studies reviewed represent a cross section of cultures and education systems.

As Table 2.4 shows, 12 studies employed a quantitative design. For example, Miller and Robertson (2011) investigated the effects of a commercial off-the-shelf computer game on children's mental computation skills and self-perceptions by randomly assigning 634 participants to two experimental conditions (gaming vs. non-treatment). The treatment period was 9 weeks with experimental children playing a 'brain training' game with a games console for 20 minutes each day.

Table 2.4: A summary of 21 empirical studies reviewed

| Study | Sample size | Age | Country | Method | Treatment | Result | Comparison group or control group? | Random allocation to conditions? | Ecological validity | Game | Other factors |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Moreno. (2002) | 61 | 5th and 6th grade | US | Quantitative method | four training sessions over a two week period | Maths performance: game with verbal representation group had significantly higher gain scores than game without verbal representation group | Yes game with verbal representation VS game without verbal representation | Yes | High- regular class time | Computer game | -Prior Maths knowledge -computer experience -Socio-status<br><br>-Language background |
| Ota & DuPaul (2002) | 3 | 4th to 6th grade | US | Quantitative method | 20 minutes each time, three to four times a week | Maths performance: modest improvement | No | No | High – in the classroom with regular class teacher | Computer game | Pupils with ADHD |
| Laffey et al.(2003) | 187 | Preschool and 1st grade | US | Quantitative method | two 20-25 minutes per week over an eight week period | Maths performance: game group had significantly higher gain scores than non-treatment group | Yes game VS non-treatment | Yes | Low – outside the regular classroom and having individual supervision by the research assistants | Computer game | -Socio-status -Including at-risk behavior problem children |
| Rosas et al. (2003) | 1274 | 1st and 2nd grade | Chile | Mixed method | 20-40 min daily during 12 weeks | Maths performance: No significant difference between gaming group and internal control group but all significant better than external controls. | Yes game VS non-treatment (internal control) VS non-treatment (external control) | No- according to educational group | Medium –regular class hours regular class teacher but with a weekly supervision of one member of the research team | Handheld game – Gameboy | |
| Fuchs et al. (2006) | 33 | 1st grade | US | Quantitative method | fifty 10-min sessions over 18 weeks | Maths performance: significant improvement on addition but not on subtraction | No | Yes – but assigned randomly in blocks within classrooms to play math game or spelling game | Low – in the classroom but researcher assistants supervised the treatment sessions in the classroom | Computer game | Maths ability |

Table 2.4 continued

| Study | Sample size | Age | Country | Method | Treatment | Result | Comparison group or control group? | Random allocation to conditions? | Ecological validity | Game | Other factors |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Shin et al. (2006) | 50 | 2nd grade | US | Quantitative method | Handheld game group played game for 15 minutes for the first ten days, after that 15 minutes three times per week for five weeks<br>Card game group played flash card activities for 15 minutes, three times per a week. | Maths performance:<br>Handheld game group had significantly higher gain scores than card game group<br><br>Attitude to mathematics: correlated significantly to students' scores on a mathematics test. | Yes<br>Handheld game group VS card game group | No- depending on teacher's preference | Medium – regular class teacher but a researcher and an assistant researcher conducted a classroom observation for both two groups twice a week | Handheld game – Gameboy | Socio-status |
| Vogel et al. (2006b) | 42 | 7 to 12 years | US | Quantitative method | 10 minutes per day for two weeks | Maths performance:<br>significant improvement on non-game CAI group but not on game CAI group | Yes<br>Game based VS non-game CAI | Yes | Low – students were taught in a segregated classroom environment | Computer game | 11 deaf children in sample |
| Ke & Grabowski (2007) | 125 | 5th grade | USA | Quantitative Method | two 40 minutes sessions each week for 4 weeks | Maths performance:<br>All 2 gaming groups outperformed no game group but no significant difference between 2 gaming groups<br><br>Attitude to mathematics:<br>Cooperative gaming group outperformed all other groups (competitive and no game) but no difference with these two groups | Yes<br>cooperative gaming VS interpersonal competitive gaming<br>VS no game group | Yes | Low –the researchers observed most game playing sessions | Web-based computer game | -computer experience -Socio-status |
| Ke (2008a) | 160 | 5th grade | USA | Quantitative Method | two 40 minutes sessions each week for 4 weeks | Maths performance:<br>All 3 gaming groups outperformed no game group but no significant difference between 3 gaming groups<br><br>Attitude to mathematics:<br>Cooperative gaming group outperformed all other groups (competitive, individualistic and no game) but no difference with these three groups | Yes<br>cooperative gaming VS interpersonal competitive gaming<br>VS individualistic gaming VS no game group | Yes | Low –the researchers observed most game playing sessions | Web-based computer game | -computer experience -Socio-status |

Table 2.4 continued

| Study | Sample size | Age | Country | Method | Treatment | Result | Comparison group or control group? | Random allocation to conditions? | Ecological validity | Game | Other factors |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ke (2008b) | 15 | 4th and 5th grade | USA | Mixed method | 10 two-hour sessions for five weeks | Maths performance: no significant difference<br><br>Attitude to mathematics: significant difference | No | No | Low – summer math program in school computer lab | Web-based computer game | -computer experience<br>-maths ability |
| Lim (2008) | 80 | Primary 5 | Singapore | Mixed method | 30 game-mediated lessons and 28 after school sessions | Attitude to mathematics: significant difference in motivation | No | No | Low – some sessions in school computer room and supervised by the part-time technical assistant and the author | Computer game | |
| Cankaya & Karamete (2009) | 176 | 7th grade | Turkey | Qualitative method | Sufficient time enough | Attitude to mathematics: develop positive attitudes towards learning maths | No | No | Low – Survey only | Computer game | |
| Costu et al. (2009) | 16 | 6th to 8th grade | Turkey | Qualitative method | One lesson | Attitude to mathematics: positive. | No | No | Low – only play game for one lesson and only using written interview with five questions | Web-based computer game | |
| Boticki et al. (2010) | 16 | Primary 3 | Singapore | Qualitative method | More than half a year | Maths performance: No impact on learning | No | No | Low –Interview only | Mobile phone software | |
| Miller & Robertson (2010) | 71 | Primary 6 | UK | Quantitative method | 20 minutes per day for 10 weeks | Maths performance: Significant gains for game group<br>Mixed results for two controls | Yes<br>game group VS 'Brain Gym' group VS non-treatment | No- purposive sampling | High – regular classroom and regular teacher | Nintendo's DS game | |
| Yang & Chen (2010) | 34 | 5th grade | Taiwan | Quantitative method | 60 minutes | Maths performance: positive | No | No | Uncertain | Computer game | |

Table 2.4 continued

| Study | Sample size | Age | Country | Method | Treatment | Result | Comparison group or control group? | Random allocation to conditions? | Ecological validity | Game | Other factors |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ramos, Legaspi & Doroja (2011) | A few | Elementary students | Philippines | Uncertain methods | Three to four hours daily for two weeks | Students enjoyed playing the game and found the game effective as a whole. | Uncertain | Uncertain | Uncertain | Mobile phone game | |
| Graven & Scott (2011) | 22 | 3rd to 5th grade | South Africa | Uncertain methods | One hour workshop | Positive feedback from both students and teacher | No | No | Low – only play game for one hour | Online game | |
| Main & O'Rourke (2011) | 59 | 4th and 5th grade | Australia | Mixed method | 20 minutes per day for 10 week intervention | Maths performance: Significant improvement | Yes<br>Game VS non-treatment | No | High – regular classroom with regular teacher but weekly visit to both schools by a researcher assistant | Nintendo's DS game | |
| Miller & Robertson (2011) | 634 | Primary 6 | UK | Quantitative method | 20 minutes per day for 9 weeks | Maths performance: Significant improvement | Yes<br>game VS non-treatment | Yes | High – normal classroom activity regular class teacher | Nintendo's DS game | |
| Pareto et al.(2011) | 153 | 3rd and 5th grade | Sweden | Quantitative method | One 40-minute session per week for 9 weeks | Maths performance: positive<br><br>Attitude towards maths: no impact | Yes<br>game VS non-treatment | No | Low – the classes at two different locations and one location had a semi-authentic setting (game play in groups of 8 monitored by researcher) | Computer game | |

The pre-post mathematics test results showed that both the game group and control group had a positive impact on their mental computation skills, but the gains in the experimental group were more than in the control group. Another study by Main and Rourke (2011) also used a quantitative method to compare the use of commercial off-the-shelf (COTS) handheld game consoles (HGCs) with traditional teaching methods to develop the automaticity of mathematical calculations for year four students (9-10 years old) in two metropolitan schools. One class conducted daily sessions using the HGCs and the Dr. Kawashima's Brain Training software to enhance their mental math skills while the comparison class engaged in mental math lessons using more traditional classroom approaches. Students were assessed using standardized mathematics tests at the beginning and completion of the treatment and findings indicated that the experimental group students showed significant improvement in both the speed and accuracy of their mathematical calculations.

Three articles used qualitative methods. For example, Costu et al. (2009) conducted a written interview to find out children's attitudes towards using game based learning in a mathematics class. They found that children have positive attitudes towards using the browser-based computer game in the classroom. Boticki, Looi and Wong (2010) found children enjoyed the learning activity using the mobile phone software from their interview data.

Four studies used mixed methods. For example, Ke (2008) employed a mixed-method approach to examine the effect of educational computer games in fourth and fifth grade children's mathematics learning and mathematics attitudes over 5 weeks. Although the researcher found evidence of more positive attitudes towards mathematics, there was no positive impact in mathematics performance. The remaining two articles did not mention their methods. In terms of data collection, four main methods were used in these empirical studies: mathematics test, surveys or questionnaires, interview and observation.

The empirical studies used different groups of variables to examine the effects of games. Sixteen studies compared mathematics performance (e.g. Miller & Robertson, 2010, 2011), and seven papers investigated attitudes towards mathematics (e.g. Ke & Grabows, 2007; Lim, 2008). It should be noted that two studies (Romos et al., 2011; Graven & Scott, 2011) did not state the variables that were used to examine the effect of games.

In addition, the results of the 21 empirical studies about games as effective learning tools for mathematics were mixed, although the majority of the reviewed empirical studies, 14 out of 21, indicated that using instructional games significantly improves learning mathematics. For example, the findings from Moreno (2002), Laffey, Espinosa, Moore and Lodree (2003), Shin, Norris and Soloway (2006), Ke and Grabowski (2007), Miller and Robertson (2010, 2011) showed that games significantly improved the learner's mathematics achievement.

However, Rosas et al. (2003) found that although the game had significantly improved children's mathematics performance, there was no significant difference between the gaming group and the internal control group. Fuchs et al. (2006) indicated that the game significantly improved addition but not subtraction. In addition, there also have been two papers which indicated that games made no clear difference in learners' mathematics achievement (Ke, 2008b; Boticki, et al., 2010). Moreover, one study had contrasting results because the researchers observed significant improvement in the non-game computer-assisted instruction but not in the game-based experimental condition (Vogel, Greenwood-Ericksen, Cannon-Bowers & Bowers, 2006b). Forty-four children aged 7 to 12 were split randomly into either the experimental group or the control group. The experimental group used the CAI program with gaming attributes for 10 minutes per day for two weeks while the control group used the CAI program without the gaming element for the same intervention time as the experimental group. The results of this study showed that the control group performed significantly better on the math post-test compared to the pre-test while the experimental group showed no significant difference. A possible reason is because of "the sharp division between the learning and game content inherent in the type of design" (Vogel et al., 2006b, p.113) where there is no clear connection between the game part and the learning part. Children may only concentrate on gaming and they were not able to pinpoint the content knowledge they learned.

Although most of the studies appear to support the value of computer games for mathematics, there are differences. What are the factors that prevent us reaching a firm conclusion about the effects of computer games?

The participants are different. The numbers of participants in the 21 empirical studies are different and participants varied from grade one to grade eight. For example, Ota and DuPaul (2002) carried out research on a sample of three pupils while 1274 children participated in the research conducted by Rosas et al. (2003). Laffey et al. (2003) studied how playing computer games affected pre-school and first grade children's mathematics achievement and Costu, Aydin and Filiz (2009) directed their research at the impact of playing games on learning mathematics in grade six to eight children.

In the 21 empirical studies, other factors may have influenced the findings. For example, differences in factors such as computer skills (Moreno, 2002; Ke & Grabowski, 2007; Yang & Chen, 2010; Pareto, Arvemo, Dahl, Haake, & Gulz, 2011), prior game playing experience (Ke & Grabowski, 2007; Ke, 2008a), English proficiency (Moreno, 2002), socioeconomic-status (Moreno, 2002; Laffey, et al., 2003; Rosas et al.; Miller & Robertson, 2011; Ke, 2008a; Pareto et al., 2011), ethnic group (Laffey et al., 2003) and gender (Ke, 2008a; Yang & Chen, 2010) were taken into account in the process of selecting the participants. In addition, there are four studies which involved special populations with special learning needs. The purpose of the study investigated by Ota and DuPaul (2002) was to examine the effects of software with a game format on the math performance of children with Attention-deficit hyperactivity disorder (ADHD). Laffey et al. (2003) investigated how playing computer games affected children with at-risk behaviour problems. Fuchs, et al. (2006) assessed the potential for computer-assisted instruction (CAI) to enhance number combination skill among children with concurrent risk for math disability. Moreover, the study conducted by Vogel et al. (2006) involved eleven deaf children out of a total 42 participants in their study.

The treatment periods were different as well and the intervention periods in 14 reviewed studies were no more than 10 weeks. Three out of 21 studies indicated that the treatment periods were around two weeks (Moreno, 2002; Ota & DuPaul, 2002; Vogel et al., 2006). But in the studies of Costu et al. (2009), Yang and Chen (2010) and Graven and Scott (2011), the intervention time is very short. Costu et al. (2009) looked into the effect of playing the game on children's attitudes towards mathematics. Participant children only played the game for one lesson. Yang and Chen (2010) focused on how children's spatial ability improvement by playing computer games. The treatment time was just 60 minutes. Graven and Scott (2011) ran a workshop for grade three to five children which aimed at exploring their experiences using a free online numeracy game. The playing time was one hour. However in the study conducted by Boticki et al. (2010), the treatment period was longest among the 21 studies. The intervention time in the study of Boticki et al. (2010) was more than half a year. Cankaya and Karamete (2009) did a survey to find out whether playing a computer game can impact children's mathematics attitudes. They didn't mention the specific treatment time but they did the survey after what they called 'sufficient game play time' (p.147).

One important factor that has hindered reaching a firm conclusion about the effects of computer games is lack of control groups in the studies. Examining the effect of a treatment without comparison with a control group is problematic (Hays, 2005; Vogel et al., 2006a). A control group is an essential part of true experimental design in educational research, allowing researchers to eliminate and isolate confounding variables and bias (Cohen, Manion & Morrison, 2007). If there is no comparison group, it is difficult to argue that game playing alone was effective or ineffective. Out of the 21 empirical studies, only eleven studies used experimental research design incorporating control and experimental groups. Among the eleven studies, three studies had two comparison groups (Rosas et al., 2003; Shin, Ke & Grabowski, 2007; Miller & Robertson, 2010) and one study had three comparison groups (Ke, 2008a).

Rosas et al. (2003) evaluated the effects of introducing educational video games into the classroom and found indications of positive effects on learning, motivation and classroom dynamics. The research was conducted in Chile by using a well-designed computer game on a sample of 1274 pupils from grade 1 to 2. They divided into three groups: experimental group, internal control group and external control group. The experimental group played computer games for 20 to 40 minutes daily over a three month period. The internal control group was in the same schools as the experimental group while the external control group did not have any contact with the experimental group. The internal control group and the external group were taught in regular classes. The results showed the results of the experimental group and the internal control group were significantly higher than the external control group but no significant differences were found between the experimental group and the internal control group.

Ke and Grabowski (2007) found that playing computer games improved children's mathematics learning in grade five of primary school. One hundred and twenty-five pupils were divided into Teams-Games-Tournament cooperative game playing group, interpersonal competitive game playing group and a no game playing group. The game playing groups played games during two 40 minute sessions each week while the no game playing group took two 40 minutes mathematics-drill sessions each week. The pupils took a mathematical test before and after the experiment. The experimental time was 4 weeks. The research results indicated no significant difference for mathematics performance between cooperative game playing and competitive game playing but both groups performed significantly better than the no-gaming group. Cooperative game playing was most effective in promoting positive math attitudes. However there was no significant difference in the outcome of mathematics attitudes between the competitive game based learning group and the control group. In a follow-up study, besides the above groups, Ke (2008a) added one more group, individualistic game based learning group. This group of children played games individually without score competition. The results were similar to Ke and Grabowski (2007) and indicated that there was no significant difference among the three gaming groups in terms of math test performance but significantly more than the paper-and-pencil drill situation. Also, the cooperative game playing group promoted positive math attitudes while there was no difference in the outcome of mathematics attitudes among the other three groups.

The work of Miller and Robertson (2010) focused on the use of the popular Hand-held game console Nintendo DS with Dr Kawashima's Brain Training to improve children's mental computational skills. The research was conducted during a 10-week period in a sample of three schools with 71 primary six children (aged 10-11 years). In School one, a class of 21 children used a games console for 20 minutes each day, running a 'brain training' game. In School two, 31 children used 'Brain Gym' techniques in their class over the treatment period. In school three, a class of 19 children acted as no-treatment controls. The results indicated that significant pre–post gains were found in the games console group for both accuracy and speed of calculations, while results for the two comparison groups were mixed. In a follow up large-scale study (Miller & Robertson, 2011) including 634 students using a brain-training console game, the experimental group played the game half an hour a day, five days a week for nine weeks and the control group kept their normal routine. The same authors found that both the control and the treatment groups showed considerable gains. However, gains for the treatment group in accuracy were more than 50% higher than those for controls and improvements in processing speed were twice those of the controls.

There were some studies with methodological flaws in research design as there was a different length of intervention between experimental group and control group. For example, Laffey, Espinosa, Moore, & Lodree (2003) employed an experimental study to evaluate the performance of students who were given interactive computer technology (ICT) to teach math skills with a comparison control group who did not have the ICT treatment. The study found that the students in the treatment group outperformed the control group. However it is difficult to draw conclusions because students in the treatment group received extra time during non-academic periods engaging in math tasks by playing ICT math games after both the treatment group and the control group received traditional classroom instruction. Similarly, the treatment time for the game group and control group were different in the study of Shin, Norris and Soloway (2006). The authors compared the experimental group playing a handheld game with a control group playing a paper card game. Though the results showed that the performance of the handheld game group children was higher than the control group, the treatment time was different. The handheld gaming group children played the game for 15 minutes, five times per week in the first ten days and then changed to 15 minutes, three times per a week for the rest of the time during a total period of five weeks instruction. However, the paper card game group did the paper card game for 15 minutes, only three times per a week for the entire five week period.

In addition, analysis of table 2.4 showed that only six of the 21 studies used random assignment technique. Random assignment is the most important technique that can be used to control confounding variables and using the process of randomization to divide the participants into two or more groups helps to create probabilistically "equivalent" group (Cohen, Manion & Morrison, 2007).

The review above indicated some reasons why it is difficult to arrive at a conclusion about the learning benefits of games. Besides the weaknesses discussed above, one characteristic is that most studies compare the game use with "business as usual". In only one study, conducted by Shin et al. (2006), the experimental group students played the game and the control group students used a paper card game to practise similar basic arithmetic skills. So there is a lack of empirical evidence comparing electronic game use with an activity which develops similar cognitive skills using traditional paper-pencil techniques.

Moreover, there is a dearth of empirical studies focusing on playing mathematics games using mobile phones in regular primary school classrooms. This literature review of empirical studies found only two studies which focused on the learning effects of using mobile phones (Boticki et al., 2010; Ramos, Legaspi, & Doroja, 2011). Biticki et al. (2010) did a research study using mobile phone software and Ramos, et al. (2011)

explored using a mobile phones mathematics game DaMath to find out children's opinion towards the game. However, Ramos, et al. (2011) did not state the methods which they used to conduct the study though they found that children enjoyed playing the game and the game was effective. More importantly, a meta-analysis review of mobile learning studies from Wu, et al. (2012) found that only four out of 164 studies focused on using the mobile phone in the primary school, and only three of the 164 articles considered mobile learning in mathematics. In conclusion, there needs to be further experimental studies to find out the effectiveness of mobile mathematics game on children's learning in a regular primary school classroom.

Furthermore, there were no studies which were conducted in the mainland of China in the 21 reviewed papers and in other literature reviews which had been undertaken associated with the evidence on using electronic games for learning purpose (Randel et al., 1992; Dempsey et al., 1996; Hays, 2005; Vogel et al., 2006b; Ke, 2009). It seemed unlikely that there were no empirical studies conducted in the mainland of China. One possible explanation was there were no published studies which were written in English. So the researcher tried to search for Chinese publications in Chinese Language.

In order to search the Chinese literature, it is better to use a Chinese literature database. China National Knowledge Infrastructure (CNKI) is a key national academic database with e-journals, dissertations, newspapers, proceedings, year books and reference works and etc. A literature search was performed by searching this database to identify empirical studies using electronic games for mathematics learning at primary school from year 2000 onwards. The search terms used were "电脑游戏 (computer game) "

OR “电子游戏 (electronic game)” OR “教育游戏 (educational game)”.One thousand seven hundred and sixty-seven results were returned. In order to limit the findings into primary school education and empirical study, I included the search term: “小学 (primary school)” AND “实证研究(empirical study)”. Twenty papers were returned, one of which was a Master thesis reporting an empirical study involving the use of computer games for English learning at primary school (Zhong, 2012). If I changed the search term: “小学 (primary school)” AND “实证研究 (empirical study)” to “小学 (primary school)” AND “应用 (application)”, there were 187 papers returned. However, only 50 research articles were identified which conducted an empirical study. After reviewing all these papers, I excluded the articles focusing on learning English (e.g. Li, 2010), learning science (e.g Shui, 2011), learning information technology (e.g. Jing, 2007), or learning Chinese (e.g. Zhong, 2012). Four papers were found focusing on the effectiveness of using electronic games with primary school children for mathematics learning as shown in Table 2.5.

In these four studies, there were three Master theses and one journal paper. As Table 2.5 shows, among these studies, one study used a quantitative design, one used a qualitative design and the other two used a mixed methods design to investigate using computer game in children’s mathematics learning. The games used in these four studies were educational games, which were designed for learning specific mathematics knowledge, such as learning the concept of angle and how to measure an angle, or learning the concept of square kilometres.

Table 2.5: A summary of 4 empirical studies in the mainland of China

| Study | N=? | Age | method | Treatment | Output measures? | Comparison group or Control group? | Random allocation to conditions? | Ecological validity |
|---|---|---|---|---|---|---|---|---|
| Yu (2007) | one class | Primary 4 | Qualitative | Six weeks | Children improved their mathematics improvement from teacher's interview | No | No | High –in the classroom with regular teacher |
| Lv (2009) | 47 | Primary 4 | Mixed | Three lessons | Mathematics performance was better than control group after comparing the passing rates and excellent rates | Yes | No | High –in the classroom with regular teacher |
| Zhu (2011) | 45 | Primary 5 | Mixed | a month | Mathematics performance was better than control group after comparing the passing rates and excellent rates | Yes | No | High –in the classroom with regular teacher |
| Shen (2012) | one class | Primary 1 | Quantitative | uncertainty | Significantly improved the mathematics performance with lower mathematics ability students | Yes | No | High –in the classroom with regular teacher |

Overall, all four studies indicated that computer games can improve children's mathematics learning. In the studies by Lv (2009) and Zhu (2011), they both found that mathematics performance in gaming class was better than control group after comparing the pass rates and the percentage of outstanding students in each class. However, these two studies only used post-test scores and compared the scores of the experimental group and control group without statistical analysis. So we cannot rule out the possibility that these differences could have arisen by chance. Moreover, in Yu (2007)'s study the author found that children improved their mathematics performance based solely on one interview with the class teacher. The reliability of the result may be doubtful because the result was based on only one data source without triangulation. There was one study (Shen, 2012) conducted a T-test to compare the pre-test and post-test score and showed a significant improvement for children with lower mathematics ability students after game playing. However, Shen (2012) also stated that there was no difference between the students with medium or higher mathematics ability.

In all, the research on the use of electronic game for children's mathematics learning is limited; this finding confirmed the conclusion reached by Li (2007) that there was a lack of research in the application of computer games in the class. Currently in China, teachers must complete the task of teaching the curriculum using text books and no teacher would be expected to use electronic games in class unless it became part of the curriculum (Anyaegbu, Ting & Li, 2011). Limited time and space in their curriculum may hinder teachers from using electronic games in the classroom and concerns over their own efficacy in using them, along with anxiety about possible failures are also major obstacles (Purcell, 2005). However, the success in many studies which involved using games has enabled staff to take risks in the classroom (Williamson, 2009). So there need to be more evidence to show the effectiveness of using electronic games for mathematics learning in the classroom and encourage teachers to use electronic games in class.

In a summary, there is a rapidly growing interest and body of research in game based learning and there is well-documented research on using electronic games to support children's mathematics learning in the classroom. Although there are many positive results, there are some inconsistent results of the effectiveness of gaming on learning. The research evidence in relation to the effectiveness of instructional games is still somewhat limited (e.g. Hays, 2005).

# CHAPTER 3 OVERVIEW OF RESEARCH PROJECTS

## 3.1 INTRODUCTION

This chapter will summarise the key issues from the literature review and propose the research questions for this thesis. Also, a brief overview is provided of three studies which were undertaken to try to answer the research questions. Following this, an overview of the methodological approach that was used to gather the data for the study is provided. A summary of some key aspects of inferential statistics is presented after that. Human ethics considerations will be addressed at the end.

## 3.2 ISSUES FROM THE LITERATURE REVIEW

Many studies have examined children's electronic game time commitment (e.g. Phillips, Rolls, Rouse, & Griffiths, 1995; Buchman & Funk, 1996; Griffiths, 1997; Fromme, 2003; Pratchett, 2005), types of electronic games played (e.g. Phillips, et al.,1995; Kafai, 1996; Griffiths, 1997; Subrahmanyam & Greenfield, 1998; Fromme, 2003; Sherry, Lucas, Greenberg, & Lachlan, 2006), reasons for gaming (e.g. Phillips, et al.,1995; Griffiths, 1997; Fromme, 2003; Lucas & Sherry, 2004) and the social context of game playing (e.g. Mitchell, 1985; Griffiths, 1997; McFarlane, Sparrowhawk, & Heald, 2002; Fromme, 2003). However, there appears to be little research which gives a whole picture of how children use video and computer games, what games they play, who they play with and the reason for gaming. Also, there are few studies which have been conducted with Scottish children.

In addition, most of the studies examined children's electronic gaming cultures within one country, while studies which have focused on the electronic game usage patterns with different cultural background are rare. One recent research study has examined British and Chinese cultural differences in attitudes towards, and use of, the Internet (Li & Kirkup, 2007). Cross-cultural comparisons are needed to give a better understanding of student's use of electronic games in different national cultural backgrounds.

Furthermore, today's children have been involved in and use digital media from an early age; to give them a meaningful education it is important to know what they are thinking and learning about their digital experiences (Prensky, 2001). It was with this in mind that the current study was planned.

With the popularity of electronic game playing, researchers and educators are interested in using electronic games in an educational setting to enhance learning outcomes (e.g. Prensky, 2001; Gee, 2003; Squire, 2003). However both ‘‘good news’’ and ‘‘bad news’’ on electronic game effects have emerged from the research. Moreover, there is no universal agreement on the effectiveness of gaming on learning at this point. It is still important to conduct studies to see the impact of electronic games on students' achievement. From the literature review in Chapter Two, it emerged that only two empirical studies have investigated mobile phone games for children's mathematics learning in the classroom (Boticki et al., 2010; Ramos, Legaspi, & Doroja, 2011). Though there were some outstanding studies which using handheld devices to support children's mathematics learning in the classroom (e.g. Rosas et al., 2003; Miller & Robertson, 2010, 2011), handheld devices used in these studies, such as Nintendo DS or

Nintendo Gameboy, are relatively expensive. Normally these handheld devices cost about hundred and fifty pounds which has considerable implications for school finances. Besides the cost of the game system, the electronic game which can be played on Nintendo DS or Nintendo Gameboy is also expensive. On the other hand, a cheap phone only cost around 20 pounds.

However, the findings from the studies using mobile phone games to support children's learning in the literature review (Chapter Two) have limitations. There were no consistent findings about effectiveness of mobile phone game: Boticki et al. (2010) found no impact while Ramos, Legaspi and Doroja (2011) indicated the effectiveness of game play. Moreover, Boticki et al.'s (2010) finding was only based on children's interviews and Ramos, et al. (2011) did not state how they found the effectiveness of game play in this study. Therefore studies of game impact with low cost mobile phone game need to be carried out.

Apart from much attention on the effect of electronic games to support children's mathematics learning, there has been research on using non-electronic games for learning (e.g Bright, Harvey, & Wheeler, 1979; Ernest, 1986; Hughes, 1986; Rowe, 2001; Bragg, 2007). Many researchers have found positive effects on learning. For example, dice games have significantly improved children's counting skills (Hughes, 1986) and card games have had positive effects on children's mental mathematics (Rowe, 2011). However, very few studies have compared the effect of using electronic games with non-electronic games for children's mathematics learning. More research is needed to compare different learning approaches that help students learn mathematics using game-type activities. Such research findings could help the teacher integrate electronic games or other non-electronic games into their instructional practices.

## 3.3 RESEARCH QUESTIONS

Based on above analysis, three main research questions were addressed:

- What are the views of children in Scotland and China about electronic game playing?
- What is the effect of a mobile phone game on children's mathematics learning?
- Does a computer game improve children's performance and attitudes when mathematics content and process are controlled for?

## 3.4 OUTLINE OF THE RESEARCH STUDIES

The research started with a study which explored primary school children's electronic game use in their everyday life and tried to provide a clear picture of their attitudes towards game playing and how they played games within their family and peer groups. The aim was to find out the time commitment of children's game playing and get a better understanding of how, what, who and why the primary school children play electronic games in two countries: UK and China. In the next investigation, an experimental study was conducted to investigate the effect of a mobile phone game on primary school children's mathematics learning in the classroom. Finally, an experimental study was conducted to compare the effectiveness of electronic game (online mathematics game) with a non-electronic game (card activity game) on primary school children's mathematics learning in the classroom.

## 3.5 OVERVIEW OF RESEARCH METHODOLOGY

This section will discuss qualitative and quantitative methods, describe how qualitative and quantitative methods can complement each other and explain the reason for choosing mixed method research.

During the 1980s, the debate between advocates of quantitative and qualitative research reached a new peak (Tashakkori & Teddlie, 1998; Johnson & Christensen, 2007) and each group argued that their respective approach was superior. In fact, these two research approaches have their respective characteristics. For example, quantitative and qualitative research employ two different approaches to research phenomena. Quantitative research is generally focused on hypothesis testing and theory testing but qualitative research has its origins in descriptive analysis and reasoning from the specific situation to a general conclusion. However, the essential difference between qualitative and quantitative research is not only reflected in these characteristics; the way of presenting data is different. Qualitative research describes phenomena in words instead of numbers or measures but quantitative research describes phenomena in numbers and measures instead of words (Krathwohl, 1993, p. 740). Qualitative research relies on "meaning, concepts, context, descriptions, and settings" (Picciano, 2004, p. 32) and quantitative research relies on "the collection of numerical data which are then subjected to analysis using statistical routines" (Picciano, 2004, p. 51). But this not to suggest that quantitative research is only based on description, it is also about helping to explain phenomena. Babbie (2007, p.443) defined quantitative research as "the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect" whereas qualitative method features "the non-numerical examination and interpretation of observations, for the purpose of discovering underlying meanings and patterns of relationships" (Babbie, 2007, p.415). These statements emphasise that quantitative research focuses on mathematical and analytical interpretations of different correlations among variables, and qualitative research has the strong potential for revealing and explaining phenomena.

Every method has its own strength and weakness. Quantitative research is "weak in understanding the context or setting in which people talk. Also, the voices of participants are not directly heard in most quantitative research" (Creswell & Plano Clark, 2007, p.9). Qualitative research can make up for these weaknesses because qualitative research allowed the researcher to study the phenomenon in natural environments and understand people and the social context within which they live. On the other hand, qualitative research has some weaknesses because of "the personal interpretations made by the researcher, the ensuing bias created by this, and the difficulty in generalizing findings to a large group because of the limited number of participants studied" (Creswell & Plano Clark, 2007, p.9). Quantitative research, it is argued, does not have these weaknesses.

It can be argued that there should not be a contradiction between these two methods, but quantitative and qualitative techniques can and should co-exist as potential tools. Despite these differences between qualitative and quantitative research, both methods can be applied within one investigation (Bryman, 1992; Creswell & Plano Clark, 2007). It should be possible to bring them together by utilizing the strengths and limiting the weakness of both methods. There is wide consensus that mixing different types of methods can strengthen a study and offer comprehensive evidence and more convincing results for studying a research problem than either quantitative or qualitative research alone (e.g. Muijs, 2004; Ross & Morrison, 2004; Creswell & Plano Clark, 2007). Mixed methods "offers strengths that offset the weaknesses of separately applied quantitative and qualitative research methods" (Creswell & Plano Clark, 2007, p.18).

In fact, the mixed methods approach has emerged as a third approach alongside quantitative and qualitative approaches (Creswell, 2003). Tashakkori and Teddlie (2003) also called mixed methods research the "third methodological movement" (p.ix). Johnson and Onwuegbuzie (2004) claimed 'considering mixed methods as a legitimate design in educational research' (p.16). Creswell and Plano Clark (2007) stated that a special interest group on mixed methods research has been formed in the American Educational Research Association and Sage Publications also has a journal called the Journal of Mixed Methods Research that is devoted to publishing mixed methods studies and discussions about the methodology of mixed methods research.

Mixed methods research helps answer questions that cannot be answered by qualitative or quantitative approaches alone. For example, Creswell (2009) discussed that "How do the interviews with teachers help to explain any quantitative differences in achievement for middle school and junior high students?" (p.140) is a mixed methods question which should use qualitative data to explain the quantitative results, like "How to explain the quantitative results of a study?" (Creswell & Plano Clark, 2007, p.9). To answer these questions, neither quantitative nor qualitative approaches on their own would provide a complete answer. Integrated qualitative and quantitative techniques offer more potential to answer the research questions as described in the following quote:

> "The most persuasive policy research includes both of these elements: numbers that define the scope and patterns of the problem, and a story that shows how the problem works in daily life and provides for empathetic understanding. These two elements stem from quantitative and qualitative research." (Spalter-Roth, 2000, p. 48)

From the view of Creswell & Plano Clark (2007), it is natural for individuals to use mixed methods research as the preferred mode of understanding the world. Creswell & Plano Clark (2007) listed an example: "When people talk about the Katrina devastation in the southern United States, both words and numbers come to mind. This type of talk is not only more natural, it is also more persuasive than either words or numbers by themselves in presenting a complete picture of the devastation." (Creswell & Plano Clark, 2007, p.10). That is, the use of numbers and words in combination provides a better understanding of the phenomenon of the Katrina devastation than either words or numbers alone.

So quantitative design (e.g., experiment or correlational study) can be enhanced by qualitative data, or a qualitative design (e.g., grounded theory or case study) can be enhanced by quantitative data; thus a mixed methods design is the preferred design (Creswell & Plano Clark, 2007). In the light of the discussion above, in the current study I gathered quantitative data (e.g. performance data, in the field of numbers attempted, correct answers to sums, and time taken to complete tasks) and also qualitative data (e.g. interview asking for opinions, observation). In this research, the qualitative data explored in more depth the context of children's electronic game playing; helped the researcher explain the quantitative results; and explored the reasons for the game effects on the participants. More details about the exact methods for each part of the study are provided in the following chapters four, five and six.

## 3.6 INFERENTIAL STATISTICS

### 3.6.1 WHAT ARE INFERENTIAL STATISTICS?

Asadoorian and Kantarelis (2005) defined statistics as 'the science of collecting, organizing, analysing, and interpreting data in order to make decisions' (p.2). There are two major categories of statistics: descriptive and inferential statistics. Descriptive statistics involve 'procedures used to summarize and describe the important characteristics of a set of measurements' (Mendenhall, Beaver & Beaver, 2012, p.4). These statistics report and describe what has been found from data. For example, the mean (average) score, the minimum or maximum scores of the data or the summary of frequencies are descriptive statistics. Descriptive statistics are straightforward presentation of facts.

Compared with descriptive statistics, inferential statistics consist of ‘procedures used to make inferences about population characteristics from information contained in a sample drawn from this population’ (Mendenhall, Beaver & Beaver, 2012, p.4). Inferential statistics allow us to take the results of an analysis using a sample and generalize our findings to the larger population. For example, we may want to ask the students in a University their opinion about finding a job after graduating. We would probably take the results of an analysis using a representative sample of individuals in this university in the hopes of finding out how the students in the university as a whole view their job hunting.

Inferential statistics can be used to test the probability that findings are dependable. Inferential statistics can tell us the probability that we have confidence in the findings or the results of the analysis could have occurred by chance. Kirk (1999) indicated that “a statistically significant result is one for which chance is an unlikely explanation” (p.337). For example, if tests show us that the results are not statistically significant, it means we cannot rule out chance factors. However, if the tests indicate that the findings are statistically significant, this means that we can have confidence that it is not due to chance factors.

### 3.6.2 SOME EXAMPLES OF INFERENTIAL STATISTICS

Inferential statistics enable the researcher to test hypotheses about the generalisability of the findings from a sample to a wider population (Cohen, Manion & Morrison, 2011). There are a range of different types of inferential statistics which may be applied to the data. These include measuring the difference between groups, the t-test, analysis of variance, the Chi-square test, degrees of freedom, the Mann-Whitney U tests, the Kruskal-Wallis and Friedman test and regression analysis (Cohen et al, 2011)

There are some factors to consider when deciding which statistic to employ: the type of data, the number of groups being compared or whether the groups are related or independent (Cohen et al, 2011). For example, with categorical data, the Chi-square test can be used to test the probability that one frequency distribution is the same as (or different from) another one when analyses the categorical data (i.e., investigate possible differences among the students' choices by gender). Chi-square test is a non-parametric test used to compare patterns of responses or frequencies. On the other hand, if the data is parametric data and we try to find out the difference between two groups, the t-test can be used. The t-test is used to discover whether there are statistically significant differences between the means of two groups. The t-test has two variants and can be used for independent samples and for related samples. If we want to compare mean scores of more than two groups, we can use Analysis of Variance (ANOVA) to determine if the groups have significantly different means. Multivariate regression is used when you have more than one independent (causal) variable and one dependent (effect or outcome) variable because you are not only want to know if your intervention has an impact on the outcome, but you also want to know which aspects of your intervention have an impact and/or the relative impact of different aspects of your intervention. So these different statistics are powerful tools for analysing numerical data (Cohen et al, 2011).

### 3.6.3 HOW DO WE INTERPRET THEM?

Statistical significance is about determining the probability that the findings could have occurred by chance. Three probability values may be employed to assess statistical significance, namely $p<0.001$, $p<0.01$ and $p<0.05$. It has been common practice to interpret a *p* value by examining whether it is smaller than 0.05. The *p* value that is very small indicates that the observed effect is very unlikely to have arisen purely by chance, For example, if the researcher is interested to find whether there are differences between two groups, and the p value is smaller than 0.05, we can say that the difference between the two groups is statistically significant; it is unlikely to have arisen by chance. If the p value is bigger than 0.05, this indicates that the difference is “non-significant”. This means that we cannot rule out chance factors.

### 3.6.4 HOW WILL I USE THEM IN THIS STUDY?

In this study inferential statistics will be used to tell us the probability that the results of the analysis of difference between boys and girls in respect of their opinions towards electronic game playing, or the change in participants between a pretest and a post-test could have occurred by chance. The Chi-square or T-test will be used to test for statistical significance in this study. The Chi-square test will be used in study One to compare the patterns of boys' and girls' views on playing electronic games. The T-test will be used in all three studies to compare the mean scores of different groups to see if they are significantly different.

Cohen, Manion & Morrison (2007) indicated that results that are non-significant "should not dismay the researcher; finding or not finding a statistically significant difference is of equal value in research – a win-win situation" (p.545). Finding no difference can be as important as finding a difference. So in this thesis it will be equally important to look at the evidence of non-significant findings which emerge from the data.

## 3.7 HUMAN ETHICS CONSIDERATIONS

The studies undertaken for this thesis were conducted following the ethical guidelines of the School of Education, Social Work and Community Education at the University of Dundee. Participants' rights were taken into full consideration. Prior to the each study, participants were given a full research agenda. All participants' parents were asked to sign a parental permission form. In it, it was clearly stated what the project's aims were and how children would be involved. I took care that they understood their participation was voluntary and they did not feel coerced to participate. Participants were informed they were free to withdraw from the study at any time if they were uncomfortable with any of the details of the study and that the results of the study would be made available to them should they wish to receive them. The participants were informed that their responses would only be used for the purpose of this particular research project. The ethics application was reviewed and approved by the Dundee University Research Ethics Committee.

When storing and analysing the data, the researcher ensured the confidentiality of data and anonymity of the participants. The right to privacy was upheld through strict adherence to the guidelines set out in the Data Protection Act (1998).

Participants' interview responses were recorded digitally and the digital audio files were downloaded to a password protected computer that only the researcher could access. Also, questionnaires and transcripts of the interviews were kept in a locked file cabinet. All online data records were held on a password protected network with a back-up held in a secure office. All data were not used for any other purpose than to inform this specific study. All data were coded in order to protect participants' identity. It was stated that the researchers could access data and quote from it anonymously in future papers (Doctoral thesis, conference presentations and papers for publications).

# CHAPTER 4 STUDY ONE - CHILDREN'S ATTITUDES TOWARDS ELECTRONIC GAMES IN SCOTLAND AND CHINA

This study aimed to find out primary school children's views and behaviours about electronic games in Scotland and China. This study was based on a questionnaire survey. Oppenheim (2000, p.100) argued that a questionnaire is an important instrument of research and a useful tool for data collection; they can give a large amount of information in a short time. A well-constructed questionnaire is able to provide extremely accurate insights into how students think and the way they evaluate situations and experiences (Reid, 2003). There are two kinds of questions when developing a questionnaire: open-ended questions and closed questions. In open-ended questions, the respondent should write down what he/she thinks. Open-end questions ask the respondents to express their opinions in their own words and there is freedom for the respondents (Oppenheim, 2000, p.112). Such questions can yield greater depth of information especially of personal individual issues (Blaxter, Hughes & Tight, 1996). However, they can be difficult to interpret and analyse. In closed questions, the questionnaire developer writes the answers for the respondent to choose from. These questions may be harder for the questionnaire developer to design the answers and can lead to problems – for example, that the answers do not reflect how the respondents really think. However, they are much simpler to analyse and compare between students (Oppenheim, 2000).

When developing a questionnaire, it is important to be familiar with possible types of questions and to choose the types which can provide the information for what a researcher would like to know for each question and suit the students who participate in the study (Reid, 2003). In order to collect information about children's attitudes towards electronic games, the researcher created three questionnaires with a mixture of both types of questions. Two questionnaires investigated Scottish children's time spent on and attitudes towards, electronic games and mobile phone games. Another questionnaire explored Chinese children's time spent on and thoughts about electronic games and mobile phone games.

The questionnaires were designed to answer the following questions:

1. How often and how long do Scottish children spend on electronic games?
2. What are Scottish children's attitudes towards playing electronic games?
3. How often and how long do Chinese children spend on electronic games?
4. What are Chinese children's attitudes towards electronic games?
5. What are the differences between boys' and girls' time spent on games and their attitudes towards games?
6. What are the differences between Scottish children and Chinese children's time spent on games and their attitudes?
7. What are Scottish children's views in relation to using mobile phone and mobile phone game playing?
8. What are Chinese children's characteristics in relation to using mobile phone and mobile phone game playing?

All the methods which were used to conduct the data collection and the analysis are discussed within this chapter. This chapter also contains the findings about the children's attitudes towards electronic games in Scotland and China, and discusses these results.

**4.1 QUESTIONNAIRE ONE**

The first questionnaire was designed to investigate Scottish children's views on electronic games playing. As discussed in Chapter one (see Section 1.4), this thesis selected "electronic game" rather than "computer games", "video games" or "digital games" to represent all the games on all game systems such as PC, Playstation, Xbox, Nintendo's, PSP, Gameboy, and mobiles. However, in this questionnaire, the researcher used "electronic/computer games" to represent all the games because this questionnaire was designed at the beginning of the research journey. The researcher also wanted to learn more about the pattern of children's electronic games use in their everyday life and the social context of children's gaming cultures, for example, who do children like playing electronic games with, or talk about games with? See appendix A for copy of this questionnaire. More details about this questionnaire are discussed in the following sections.

4.1.1 METHODOLOGY

The researcher will present information about this questionnaire and all the methods which were used to conduct the data collection and data analysis are also discussed within the section.

#### 4.1.1.1 Participants

The participants were a convenience sample. Because the research was targeted on primary school students, and the primary schools had to be located in the Dundee City area and be easy to approach by bus, the researcher sent the requests to some possible primary school teachers with the help of her supervisors. A P5 class teacher in a Dundee city primary school was happy to participate. This school was situated in Dundee and followed the normal Scottish primary school curriculum. The participants for this questionnaire survey consisted of a total of 21 Scottish students (11 boys and 10 girls) aged between 9 and 11.

#### 4.1.1.2 Research instruments

The first questionnaire consisted of thirty-three items and involved many different question formats:

(1) Free text question: The first item in this questionnaire referred to the favourite games of the children using this method. In order to reduce the complexity of the

questionnaire and seek more information on children's favourite games, the researcher decided to ask the children to write down the names of their current favourite electronic games.

(2) The researcher adopted a multiple-choice method in four questionnaire items; there were specific options and children could tick these. One of the advantages of multiple choice questions is that they give the researcher clear categories of answers and are easy to analyse.

a. Single tick questions: there are three items which children were asked to select only one option from a list. For example, students were asked how often they play electronic games. Pupils could choose from the following options: Everyday, At least once a week, Once or twice a month.

b. Multiple tick questions: one item question asked children to select one or more of the choices from a list. This question tried to find out what game systems children own. The researcher listed eleven choices which included nine game systems such as PC gaming, Playstation, Xbox, Nintendo DS etc. (See Appendix A for details), one choice for children who didn't own any game system and last choice was "Other system" which allowed children to write down the system name to elaborate.

(3) Continuous rating scale (also called the graphic rating scale) was used in the remaining 28 items of this questionnaire. A continuous rating scale consists of a line with two fixed points on either end. The line is labeled initially by a graphic, happy face

and sad face and numbers zero and 100 at each end. Children are asked to rate items by placing a mark on the line. It is believed that a continuous rating scale is suitable for children and children find the attitude scale easier and more interesting because of the marking. Stanley & Jenkins (2007, p.92) investigated the general acceptance of continuous rating scales and concluded that "many respondents across all ages found the graphical inputs acceptable, enjoyed completing the questionnaire and were looking forward to more surveys of this type in the future."

However, every method has its own strengths and weaknesses. The disadvantages of using a continuous rating scale are as following:

a. Scoring and codification is difficult.
b. It can cost a substantial amount of time. The researcher has to measure the physical distance on the scale for each respondent.
c. Respondents may not be capable of perceiving fine differences in the attitudes on a straight line.

In order to overcome these difficulties, the researcher designed the length of whole line to be 100 millimeter. This helped the researcher to measure the physical distance by ruler and changed the mark to scale points from 0 to 100 when analysing the questionnaire.

These 28 questions were used to gain information on children's opinions about the social context of children's gaming cultures. 15 items of them tried to find out children's views from the four categories:

a. who do children like playing together with (with parents; with brothers or sisters; with friends or alone)?

   This 'playing' means any motivated activities associated with pleasure and enjoyment, for example, playing with games, toys, playing inside or outside activities etc.

b. who do children like playing electronic games with (with parents, uncles, aunts or grandparents; with boys; with girls or alone)?

c. who do children like talking about electronic games with (with parents, uncles, aunts or grandparents; with boys; with girls)?

d. who teaches children to play electronic games (teach by themselves; parents , uncles, aunts or grandparents teach; boys teach; girls teach)?

Nine questions were used to find out in which situations the children decided to play electronic games and why they like playing electronic games. The researcher listed four situations: boring situations, when I don't want to do my homework, when friends come to my home, or as often as possible (in any possible situation). This was not to analyse the motivation factor of electronic games but to have a look at possible situations in which children would tend to play computer games. When asking about their motives for playing, five possible reasons were given: because games are fun, because I want to defeat my friends, because games are exciting, because I learn from games and because I want to get a high score.

The remaining four items were about children’s attitudes towards game playing, parents’ views about children’s game playing (from children’s perspective), children’s views about study at school, and children’s views about playing electronic games at school.

Besides these thirty-three items in this questionnaire, the researcher asked children to write down their name, class, name of school, male or female, date of birth and number of sisters or brothers on the first page of questionnaire.

#### 4.1.1.3 Procedure

The questionnaires were distributed in September 2006 and were handed out to the pupils and collected during regular class time by the researcher. The purpose of the research and the procedure were explained. Participants were informed that they were free to withdraw from the study at any time if they felt uncomfortable with any of the details of the study, that we were looking for their own opinions and that all personal data we collected would be confidential. The researcher also asked the children whether they had played electronic games before they did the questionnaire and explained that electronic games included games on all game systems such as PC, Playstation, Xbox, Nintendo’s, PSP, Gameboy and mobile. If anyone had not played electronic games before, they wouldn’t need to do this questionnaire. All respondents replied that they had engaged in playing electronic games before. All the 28 continuous rating scale items in the questionnaire were read by the class teacher one by one because he could help to ensure children understood the meaning of each sentence. If children did not understand they were helped by the teacher or the researcher. The questionnaire took around 40 minutes to complete and the researcher took the questionnaires away at the end. All the data were coded and analysed using the SPSS Version 14.0 statistical package. The researcher changed the mark made by the children in the continuous rating scale items to scale points from 0 to 100 by using a ruler, because the length of the whole line was 100 millimeter.

Once the questionnaire had been scored, the responses of the children were summarized. In order to investigate differences on the basis of gender, Chi-Square test and t-test statistics were used. The Chi-square test is one of the most widely used theoretical probability distributions in statistical significance tests. Chi-square test is a non-parametric test used to compare patterns of responses or frequencies. It was used in this study to compare the pattern difference of boys' and girls' choices based on the different categories in the multiple-choice questionnaire items. The T-test compares the mean scores of two set of measurements to see if they are significantly different. The questionnaire items using a continuous rating scale were analysed by T-test to look for any difference in the mean scores of boys' and girls' responses.

### 4.1.2 FINDINGS

This section analyses the findings of Scottish children's views on electronic games. Twenty-one Scottish primary students, including 10 girls and 11 boys, finished the questionnaire. This section will be divided into three parts. The first part will focus on the Scottish children's views relating to game systems they own at home and the pattern of time spent on game playing, for example, the frequency of game playing, the times when they play games at home, and the time spent on games playing each day. As discussed above, all these data were collected from the parts of the questionnaire where children ticked the options from the multiple-choice items. The patterns of response will also be analysed by gender. All findings will be presented in section 4.1.2.1. The second part will present the findings about children's attitudes towards playing, relating to whether they like playing, who they like playing with. The findings will be shown in section 4.1.2.2. The findings about whether primary students like playing electronic games, who they like playing electronic games with, when they like playing electronic games, who teaches them to play electronic games, who do they talking about electronic games with, and why they like playing electronic games will be presented in section 4.1.2.3.

#### 4.1.2.1Scottish children's game use

4.1.2.1.1 Game systems Scottish Children owned at home

Figure 4.1.1 below summarises the game systems owned by the children at home in Scottish sample.

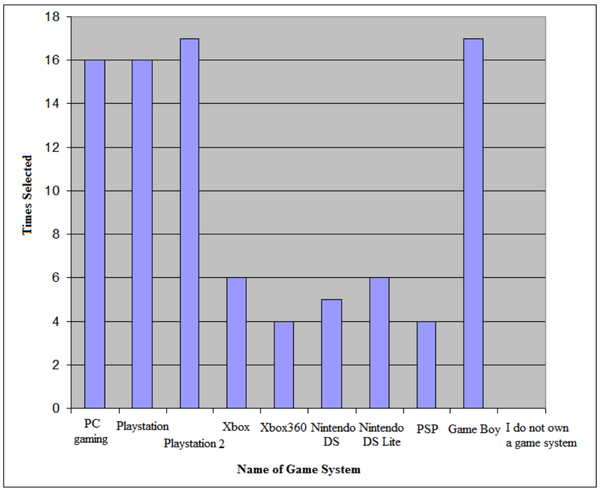


Figure 4.1.1: game systems owned by the children (Scottish sample)

Table 4.1.1 below summarises the amount of game systems owned by the children at home in Scottish sample.

Table 4.1.1: percent who live in homes with game system (Scottish sample)

| Game system | At least one system | Two systems | Three or more systems |
|---|---|---|---|
| Number of Children | 21 | 20 | 18 |
| % of Total | 100% | 95% | 86% |

Hundred percent of the children in Scotland who were surveyed have at least one game system at home. 86% of them have 3 or more game systems in their home. Sony Playstation, Game Boy and Computer are the most three popular devices at home. These data imply that children's homes are saturated with various game devices and children have more chance and more choice to play electronic game at home.

4.1.2.1.2 Frequency of game playing of children from Scottish Sample

The Table 4.1.2 below summarises the categories by frequency of game playing as found in the children in this study.

Table 4.1.2: Frequency of game playing of children (Scottish Sample)

| | Everyday | At least once a week | Once or twice a month |
|---|---|---|---|
| Number of Children | 17 | 1 | 3 |
| % of Total | 81% | 4.8% | 14.3% |

It can be seen from Table 4.1.2 that the surveyed children in Scotland were extremely dedicated to their gaming. Seventeen out of 21 students (81%) played everyday.

Figure 4.1.2 and Table 4.1.3 summarises the categories by frequency of game playing by gender.

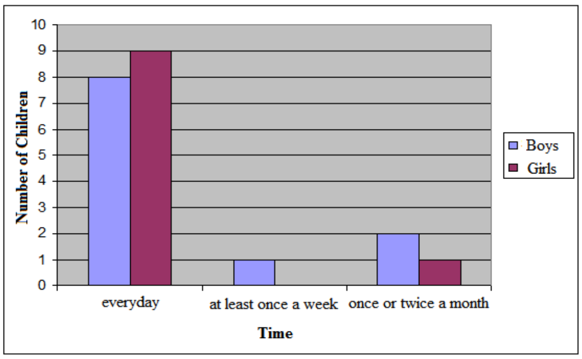


Figure 4.1.2: Frequency of game playing of boys and girls (Scottish Sample)

Table 4.1.3: Frequency of game playing of boys and girls (Scottish Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Frequency | everyday | 8 | 9 | 17 |
| | at least once a week | 1 | 0 | 1 |
| | once or twice a month | 2 | 1 | 3 |
| Total | | 11 | 10 | 21 |

It can be seen from Figure 4.1.2 that the majority of boys and girls said they played games every day. Only one of the 10 girls played once or twice a month and three of the 11 boys played at least once a week or once or twice a month.

In order to see whether any difference between boys and girls was statistically significant, the data were investigated using the Chi-square statistic (3x2 contingency tables). In this case the Chi-square tests indicated that there was no significant difference between boys and girls in their frequency of game-playing ($\chi^2(2, N = 21) = 1.35, p = .51$).

4.1.2.1.3 When do children from the Scottish Sample play games at home?

Table 4.1.4 below summarises the categories the children were in according to when they play games.

Table 4.1.4: the times when pupils play computer games at home (Scottish Sample)

| | Mostly on weekends | Mostly on weekdays | All the time |
|---|---|---|---|
| Number of Children | 4 | 0 | 17 |
| % of Total | 19% | 0% | 81% |

The data showed that eighty-one percent (17 of 21) children said that they played electronic games all the time, not just on weekdays or weekend at home.

In order to see whether any differences between boys and girls were statistically significant the data were investigated using the Chi-square test. Figure 4.1.3 shows the boys' and girls' responses separately in each category and Table 4.1.5 summarises the chi-square statistic result (3×2 contingency tables).

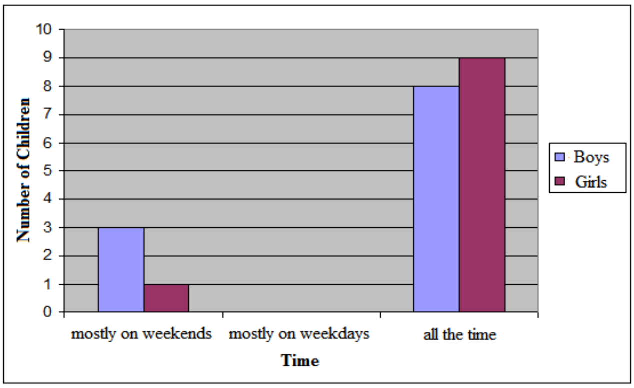


Figure 4.1.3: the times when boys and girls play computer games at home (Scottish Sample)

Table 4.1.5: the times when boys and girls play computer games at home (Scottish Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Time | all the time | 8 | 9 | 17 |
| | mostly on weekdays | 0 | 0 | 0 |
| | mostly on weekends | 3 | 1 | 4 |
| Total | | 11 | 10 | 21 |

It can be seen from Figure 4.1.3 that there was a majority of boys and girls who reported that they played games all the time, and only one girl and three boys said they played games mostly on weekends. The chi-squared test indicated there was no significant difference between boys and girls ($\chi^2(2, N = 21) = 1.01, p = .586$).

4.1.2.1.4 How long do children play games per day

Table 4.1.6 below summarises the categories the children were in with their responses according to how long they played games per day.

Table 4.1.6:time spent on games playing each day (Scottish Sample)

| | Under 30 minutes | 30 minutes to one hour | One to two hours | Over two hours |
|---|---|---|---|---|
| Number of Children | 0 | 7 | 1 | 13 |
| % of Total | 0% | 33.3% | 4.8% | 61.9% |

It can be seen from Table 4.1.6 that most of the pupils said they spent over two hours on games playing. A Chi-square test was also conducted to see whether any differences between boys and girls were statistically significant. Figure 4.1.4 and Table 4.1.7 (4×2 contingency tables) show the boys' and girls' responses separately in each category.

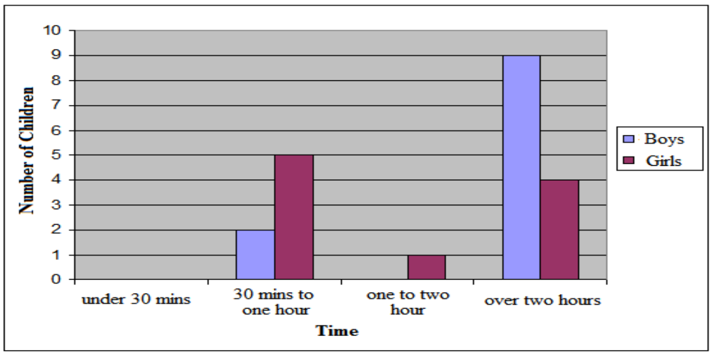


Figure 4.1.4: time spent on games playing each day by boys and girls (Scottish Sample)

Table 4.1.7: time spent on games playing each day by boys and girls (Scottish Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Time | over two hours | 9 | 4 | 13 |
| | one to two hours | 0 | 1 | 1 |
| | 30 mins to one hour | 2 | 5 | 7 |
| | Under 30 mins | 0 | 0 | 0 |
| Total | | 11 | 10 | 21 |

Figure 4.1.4 showed that nine out of eleven boys and four out of ten girls played games over two hours per day. Five out of ten girls and two out of eleven boys played games for 30 minutes to one hour a day. Only one girl reported that she spent one to two hours

per day. The chi-squared tests indicated that differences between boys and girls in this respect were not significant ($\chi^2(3, N = 21) = 4.17, p = .124$).

### 4.1.2.2 Scottish children's views on playing

This section will report the findings about children's attitudes towards playing (e.g. playing with electronic games, toys, playing inside or outside activities etc.). As explained earlier, the researcher had transformed the mark made by the children on continuous rating scale items to scale points from 0 to 100 when analysing the data.

The difference between boys and girls will also be examined in the following section using an independent-sample t-test. The independent-sample t-test was used to compare the mean score for two different groups, boys and girls, for each item. This was conducted to determine whether these differences were statistically significant.

Table 4.1.8 presents mean scores for boys' and girls' choices of who they like to play with. A higher mean score indicates a stronger preference for that particular activity.

Table 4.1.8: mean scores in relation to who children like play with (Scottish Sample)

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| I like playing alone. | 43.33 (26.52) | 40.50 (21.79) | 45.91 (31.05) | .457 | .653 |
| I like playing with my parent(s). | 56.90 (37.27) | 74.50 (34.36) | 40.91 (33.53) | -2.27 | .035 |
| I like playing with my brother(s) or sister(s). | 70.24 (35.44) | 73.50 (26.04) | 67.27 (43.38) | -.39 | .698 |
| I like playing with my friends. | 82.62 (27.23) | 87.50 (27.21) | 78.18 (27.77) | -.78 | .448 |

With the overall figures, it can be seen from table 4.1.8 that the overall mean score of each statement ranged from highest mean score (M = 82.62, SD = 27.23) for item 'I like playing with my friends.' to lowest mean score (M = 43.33, SD = 26.52) for item 'I like playing alone'. The highest scores were for children playing with friends; the lowest for playing alone. There appeared to be different patterns of scores for boys and girls for some items.

In relation to the difference between boys and girls, there was a significant difference in their response to the statement "I like playing with my parent(s)."($t(20) = -2.27$, $p<.05$). The figure indicates that girls were more likely to enjoy playing with parents than boys were. All other gender difference were non-significant ($p>.05$). This means that boys and girls did not differ in their views on the other items.

### 4.1.2.3 Scottish children's views on playing electronic game

This section will report the findings about children's attitudes towards playing and their views on playing games. The methods which were used to conduct the data collection and analysis in this section were the same as discussed in section 4.1.2.2.

4.1.2.3.1 Children's attitudes towards playing electronic games and playing electronic games at school

Mean scores for all the children and boys' and girls' response in each statement were calculated and shown in table 4.1.9. An independent-samples t-test was also conducted to compare the mean scores for each item to see whether any differences were statistically significant.

Table 4.1.9: mean scores in relation to attitudes towards playing games, playing games at school and study at school (Scottish Sample)

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| I like playing electronic/computer games. | 84.76 (23.58) | 73.00 (26.27) | 95.45 (15.08) | 2.37 | .033 |
| I like playing electronic/computer games at school. | 49.81 (35.22) | 60.50 (34.44) | 40.09 (34.59) | -1.35 | .192 |
| I like to study at school. | 53.10 (34.87) | 65.00 (32.75) | 42.27 (34.60) | -1.54 | .140 |

It can be seen from table 4.1.9 that the mean score for the item of 'I like playing electronic/computer games.' is highest (M = 84.76, SD = 23.58). This result suggested that the Scottish children liked playing electronic games. The mean score for the other two items is lower with the mean score (M = 49.81, SD = 35.22) in relation to the statement "I like playing electronic/computer games at school." and (M = 53.10, SD = 34.87) for the statement "I like to study at school." There appeared to be differences in the mean scores between boys and girls in relation to all of the items, which were then examined.

There was a significant difference between boys and girls in terms of their response to the statement "I like playing electronic/computer games". The figure indicated that boys were more positive about games than girls ($t(20) = 2.37$, $p < .05$). In the other two items the differences between boys and girls were not significant ($p > .05$). Boys and girls did not differ in their views on the other items.

4.1.2.3.2 When do children like playing electronic games?

Table 4.1.10 presents the mean points of overall response and boys' and girls' responses to the rating scale items which addressed the question "which situations the children decided to play electronic/computer games" and shows the t-test results.

<u>Table 4.1.10: mean scores in relation to possible situations in which children tend to play electronic games (Scottish Sample)</u>

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| I play electronic/computer games when I don't want to do my homework. | 43.33 (38.19) | 32.50 (29.46) | 53.18 (43.72) | 1.28 | .217 |
| Friends come to my home and I play electronic/computer games with them. | 57.62 (41.97) | 46.50 (42.50) | 67.73 (40.77) | 1.17 | .257 |
| I play electronic/computer games when I am bored. | 89.19 (18.54) | 87.80 (19.34) | 90.45 (18.64) | .32 | .752 |
| I play electronic/computer games as often as possible. | 60.95 (31.21) | 62.00 (26.48) | 60.00 (36.26) | -.14 | .888 |

In general, it can be seen from table 4.1.10, there were a range of mean scores from (M = 89.19, SD = 18.54) for the item 'I play electronic/computer games when I am bored' to (M = 43.33, SD = 38.19) for the item 'I play electronic/computer games when I don't want to do my homework'. The results suggested that Scottish children tended to played electronic/computer games when they feel bored. Boys' and girls' scores appeared to be similar on two items, but differed on the others.

Although there appeared to be differences between boys and girls in relation to the first of these two items 'I play electronic/computer games when I don't want to do my homework.' and 'Friends come to my home and I play electronic/computer games with them.', the differences were not significant (p>.05). The differences between boys and girls for the other two statements were also non-significant (p>.05). These findings indicate that boys and girls did not differ in their views on any of these items.

4.1.2.3.3 Who do children like playing game with

Table 4.1.11 presents the mean points of children's response to who they like playing electronic game with. An independent-samples t-test was used to compare the difference in mean scores.

Table 4.1.11: mean scores in relation to who children like to play game with (Scottish Sample)

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| I like playing electronic/computer games alone. | 46.43 (30.67) | 52.00 (20.98) | 41.36 (37.76) | -.79 | .441 |
| I like playing electronic/computer games with parents, uncles, aunts, grandparents. | 51.43 (32.68) | 52.50 (24.97) | 50.45 (39.65) | -.14 | .888 |
| I like playing electronic/computer games with boys. | 59.52 (37.15) | 51.00 (35.89) | 67.27 (38.23) | 1.00 | .329 |
| I like playing electronic/computer games with girls. | 48.33 (39.85) | 70.50 (30.32) | 28.18 (37.57) | -2.82 | .011 |

It can be seen from the table 4.1.11 that the overall mean scores of all the statements were around 50 points. This suggests that when looking at the children as a group, there were no clear trends. However, with gender, there appeared to be differences, particularly in relation to the third and fourth items.

The t-test indicated that there was a significant difference between boys and girls in their response to the statement "I like playing electronic/computer with girls" ($t(20) = -2.82$, $p<.05$). Girls were more likely to agree with this than boys. However, beside this significant gender difference, the differences between boys and girls in the other three items were not significant (p>.05). Boys and girls did not differ in their views about those three items.

4.1.2.3.4 Who teaches children to play electronic games?

The mean scores of items related to who teaches children to play electronic games on the questionnaire are listed below (See Table 4.1.12). An independent-sample t-test was also applied to compare the mean scores to determine whether any gender differences were significant.

Table 4.1.12: mean scores in relation to who teaches children to play computer games (Scottish Sample)

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| Parents, uncles, aunts, or grandparents teach me to play electronic/computer games. | 37.86 (32.00) | 47.00 (29.36) | 29.55 (33.35) | -1.27 | .220 |
| Boys teach me to play electronic/computer games. | 31.67 (32.76) | 52.00 (33.18) | 13.18 (19.14) | -3.24 | .006 |
| Girls teach me to play electronic/computer games. | 27.38 (30.93) | 41.00 (32.30) | 15.00 (24.90) | -2.08 | .052 |
| I teach myself to play electronic/computer games. | 68.24 (37.38) | 58.50 (38.08) | 77.09 (36.17) | 1.15 | .266 |

Looking at the overall mean scores from table 4.1.12, the most notable finding is that the mean score of children teaching themselves to play computer games is highest (M = 68.24, SD = 37.38) and nearly more than double the other three items. The mean scores of the other three statements were around 30 points. The scores for boys and girls seemed to vary considerably from item to item. The mean score of Items 1 to 3 in the table suggest that girls' mean score is bigger than boys' but the boys' mean score of item 4 is bigger than girls'.

When tested, only the second item showed significant differences for gender; this figure indicated that girls were more likely to report being taught by boys than boys themselves were ($t(20) = -3.24$, $p<.05$). All other gender differences were non-significant ($p>.05$). The inference drawn is that boys and girls did not differ on their views about these other items.

4.1.2.3.5 Who do children talk about electronic games with?

In the questionnaire, students were asked to indicate who they talk about games with: "boys", "girls" or "parents, uncles, aunts, grandparents". Table 4.1.13 presents the mean points of response to the rating scale points for the above three statements. Independent-samples t-test was conducted to compare the difference between mean scores.

Table 4.1.13: mean scores of who children talk about games with (Scottish Sample)

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| I talk about electronic/computer games with boys | 45.00 (40.40) | 29.00 (27.57) | 59.55 (45.74) | 1.87 | .079 |
| I talk about electronic/computer games with girls | 28.10 (30.56) | 43.00 (27.51) | 14.55 (27.61) | -2.36 | .029 |
| I talk about electronic/computer games with parents, uncles, aunts, grandparents | 21.43 (19.37) | 26.50 (16.84) | 16.82 (21.13) | -1.15 | .263 |

Looking at the overall scores, it can be seen that children do not seem to talk about games with others very often; all the figures are below 50%, indicating a trend to disagree with the item. This is most marked with the items which relate to talking with girls and with family members, both of which are less than 30 (the range of the scale was 1 to 100).

The most notable finding is that more girls report talking to other girls than boys do, and this is statistically significant ($t(20) = -2.36$, $p<.05$). The difference between genders in the other three items are not statistically significant ($p>.05$). The interpretation in this section is that boys and girls only differ on the second item, (I talk about electronic/computer games with girls); their views do not differ on the other items.

4.1.2.3.6 Why do children like playing electronic games?

It is interesting to analyze what motivates children to engage in computer/electronic games. The mean scores for the five statements were calculated and t-test was conducted to compare the mean scores. The results are shown in table 4.1.14.

Table 4.1.14: mean scores of why children like playing electronic game (Scottish Sample)

| Statement | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| I play electronic/computer games because they are fun. | 77.14 (25.96) | 75.50 (25.44) | 78.64 (27.58) | .27 | .790 |
| I play electronic/computer games because I want to defeat my friends. | 30.00 (32.63) | 31.00 (30.62) | 29.09 (35.83) | -.13 | .897 |
| I play electronic/computer games because they are exciting. | 56.67 (33.74) | 59.00 (25.91) | 54.55 (40.77) | -.30 | .771 |
| I play electronic/computer games because I learn from them. | 35.95 (36.73) | 44.00 (39.78) | 28.64 (33.92) | -.96 | .351 |
| I play electronic/computer games because I want to get a high score. | 47.14 (39.86) | 48.50 (39.09) | 45.91 (42.42) | -.15 | .886 |

In general, it can be seen from table 4.1.14, there was a range of overall mean scores from (M = 77.14, SD = 25.96) for the item 'I play electronic/computer games because they are fun' to (M = 30.00, SD = 32.63) for the item 'I play electronic/computer games because I want to defeat my friends'. The results indicated that children were motivated by the fun factor most. Given a midpoint of 50 on the scale, the figures in relation to items "defeat my friends", "learn from game" or "getting a high score" are below 50 points, indicating a trend to disagree with the item. The mean scores were very similar between boys and girls.

T-tests indicated that there was no significant difference between boys and girls in relation to all five statements; boys and girls did not differ in their views.

4.1.2.3.7 Parents' views about children's game playing (from children's perspective)

The mean score for this statement was calculated and t-test was conducted to compare the mean scores. The results were shown in table 4.1.15.

Table 4.1.15: mean scores of children's response to their parents' views about their game playing (Scottish Sample)

| Statement | Overall Mean | Girls' Mean | Boys' Mean | t | Sig. |
|---|---|---|---|---|---|
| My parents like me play electronic/computer games. | 54.76 | 55.50 | 54.09 | -.12 | .910 |

The mean score of this statement (M = 54.76, SD = 27.36) suggested that the parents' views (as reported by the children) did not seem to be strongly for or against games. The mean scores were very similar between boys and girls as well.

No statistically significant difference was found between genders ($p>.05$); boys and girls did not differ in their reports of their parents' views.

4.1.2.3.8 Favourite game

Fifteen of 21 children (nine boys and six girls) wrote down the names of their favourite games or wrote down their favourite game system (e.g. Nintendo DS Lite). Table 4.1.16 listed the names of girls' and boys' favourite electronic games.

Table 4.1.16: The favourite electronic games of girls and boys

| Gender | Favourite games |
|---|---|
| girls and boys | The Sims, Nintendogs, Super Mario, Spyro, FIFA, Pokemon |
| girls | The Simpsons, Guess who, Grid club, Bratz, Dance: UK, Tomb Raider, Harry Potter, Singstar, Hotel giant, Sponge Bob, Polly pocket |
| boys | Halo, Call of duty, Ghost Recon, Dream world, Grand theft auto, Driver 1&2, Small soldier, Burnout, Runescape, Wrestling, World of Warcraft & World of Warcraft : Backslicer, Diner Dash |

The girls reported their favourite games either presented active characters (e.g. Harry Potter, Sponge Bob, Simpsons, Super Mario, Spyro) or the game which simulated the real world (e.g. The Sims, Hotel giant, Nintendogs, FIFA) or puzzle games (e.g. Guessing who, Grid club) and they also showed interest in singing (e.g. Singstar), dancing (e.g. Dance: UK) or beauty (e.g. Polly pocket, Bratz).

Boys showed similar interests to girls in that they liked playing games which simulated the real world (e.g. The Sims, Nintendogs, FIFA, Diner Dash) or games with famous characters (e.g. Super Mario, Spyro). While girls reported they favour some puzzle games, boys tend to prefer playing shooting (e.g. Halo, Call of duty, Ghost Recon), racing (e.g. Grand theft auto, Driver, Burnout), and fighting (e.g. Runescape, Wrestling, Pokemon) games.

According to fifteen children (6 girls and 9 boys)'s response, girls' favourite games are the Sims (4 of 6), Nintendogs (3 of 6) and Grid club (3 of 6) while boys preferred playing Halo (5 of 9), Grand theft auto (3 of 9) and Pokemon (3 of 9). Boys tend to choose games that require higher levels of skills (e.g. Halo needs a range of visual and spatial reasoning skill in order to target the correct direction or locations and eye-hand coordination skills) and needs more strategy. By contrast, the girls tend to prefer to play games with famous characters (e.g. The Simpsons, Super Mario, etc.) or games based around dolls and beauty or some puzzle games. Girls enjoy simpler, shorter, easy-to-master and more puzzle-like games.

As an alternative way of analysing the data on favourite type of games, the researcher used the taxonomy system presented by Herz (1997) to put the games into appropriate categories. The Herz system presented eight major categories: Action, Adventure, Fighting, Role-playing, Puzzle, Simulations, Sports and Strategy games. These categorisations are used by many in the contemporary games industry (Kirriemuir & McFarlane, 2004). In the Herz system, shooting games and 'platform' games are classified as action games. However, when using this system, there are difficulties: some children reported their favourite games presented active characters (e.g. Super Mario). The Super Mario series has included a variety of different games and many different types of Mario games were created. Because the children only reported that they like playing "Super Mario", it is difficult to put into appropriate categories. So I allocated the game into category 'character' game. In addition, some games fall into more than one category. For example, "Grand theft auto" arguably fell into the categories of sports, action, adventure, role-playing games because in this game player assumes the role of protagonist (role-play) and choose missions to progress an overall story (adventure) as well as engaging in activities which consist of shooting (action), racing (sports) elements. Table 4.1.17 summarised the game type of children's favourite game by using the Herz categories.

Table 4.1.17: The game type of children's favourite electronic games

| Game type | Game name |
|---|---|
| Action | Tomb Raider; Spyro; Halo; Call of duty; Ghost Recon; Grand theft auto; Small Soldier |
| Adventure | Tomb Raider; Grand theft auto; Small Soldier; World of Warcraft; World of Warcraft: Backslicer |
| Fighting | Pokemon; Runescape; Wrestling; World of Warcraft; World of Warcraft: Backslicer |
| Role-playing | Pokemon; Grand theft auto; Runescape; World of Warcraft; World of Warcraft: Backslicer |
| Puzzle | Guess who; Grid club |
| Simulations | Bratz; Singstar; Hotel giant; Polly pocket; Dance: UK; FIFA; Nintendogs; The Sims; Dream world; Driver 1&2; Burnout; Diner Dash |
| Sports | Dance: UK; FIFA; Grand theft auto; Driver 1 & 2; Burnout |
| Strategy | Hotel giant; The Sims; Dream world; Diner Dash |
| Character | The Simpsons; Harry potter; Sponge bob; Super Mario |

*red: girls' favourite game; blue: girls' and boys' favourite games; black: boys' favourite games

It can be seen from the Table 4.1.17 that the children's favourite games included Action games (e.g. Halo, Spyro, Ghost recon), Adventure games (e.g. Grand theft auto), Simulation games (e.g. The Sims), Role-playing games (e.g. Runescape), Fighting games (e.g. Wrestling), Sports games (e.g. FIFA) and Strategy games (e.g. Diner Dash). Simulation and Action games were the most popular games.

In relation to gender difference, the picture from the Table 4.1.17 showed that the preferred types as indicated by their favourite game for boys are simulations and action games as compared to girls who played more simulations and famous characters games. Moreover, some girls responded that they liked playing “Guessing who” or “Grid club” (Puzzle games) but boys were very unlikely to mention such games. However, boys and girls reported some same favourite games, for example, ‘Nintendogs’ (Simulation game), ‘Spyro’ (Action game), ‘FIFA’ (Sports game), ‘Pokemon’ (Role-playing and fighting game) and ‘The Sims’ (Simulation and strategy game) were boys’ favourite games and also were girls’ favourite games. So the results indicated that there were some game preference differences between boys and girls but there were still some games which can attract boys and girls to play.

### 4.1.3 DISCUSSION

The purpose of this questionnaire was to examine Scottish primary students’ characteristics in regard to their use of electronic games, their electronic game preferences, and their thoughts on playing games alone or with others.

The current study clearly indicated playing electronic games is a popular leisure activity in the surveyed Scottish children. The results revealed that the surveyed students played computer games frequently and spent much time on games. The majority of children played electronic games every day and spent over two hours per day on gaming. The high percentages of game playing may be associated with the rapid development of the computer-game industry as more and more electronic games are released. The results of the current study are consistent with prior UK research such as the paper reported by Pratchett (2005) which was from the study of BBC’s Audience Research department. This research study was based on a total sample size of 3442 6-65 year olds in the UK and the result indicated that the youngest age group (6 -10 years) was extremely dedicated to their gaming. One hundred percent of them were gamers who had played a game on a mobile, handheld, console, PC, Internet or interactive TV at least once in the last six months, 95% playing several times a week and 61% playing every day and spending about 17 hours on gaming a week (Pratchett, 2005). There has been an increase in the amount of time children spend playing electronic games compared with the result of Fromme (2003) who did a European comparative study in 1997 and 1998. Fromme (2003) found that people aged between 6 and 16 spent on average 32 minutes per day playing electronic games but in the current study over two thirds children spent over an hour per day on electronic gaming. Another recent study from the UK also indicated that children aged from 8-11 spent a lot of time (average 8 hours per week) on electronic gaming since 2008 (Ofcom, 2012). This makes it possible to conclude that electronic games occupy an important place in UK young children’s lives.

In this study, boys and girls did not differ significantly in the time spent on games playing each day. This finding seemed to be different from many previous empirical studies (e.g., Buchman & Funk, 1996; Funk, Buchman, & Germann, 2000; Fromme, 2003; Bonanno & Kommers, 2005; Chou & Tsai, 2007) which reported that male children spend more time playing electronic games than females. In comparison with these previous studies, the small sample size in this study may be one of the reasons why the figures failed to reach significance. For example, in Buchman and Funk

(1996)'s study, they examined 900 children's game playing habits, and there were 367students involved in Bonanno and Kommers (2005)'s investigation. Fromme (2003) even collected a larger sample with 1,111 children. However, in the current study only 21 children completed the questionnaire. This issue will be revisited in the general discussion, when looking at the limitations of the current study. Another factor may be because this study investigated Scottish children's views on electronic games while other studies did the study in USA (Buchman & Funk, 1996) or Germany (Fromme, 2003).

However, there is evidence of change in this respect, and my results may reflect this. Some previous studies suggested that patterns of gender difference are not entirely clear-cut. Rideout, Foehr, and Roberts (2005) showed that boys ages 8–18 were spending three times as much time as girls playing video games in 2005; however, this difference had changed from triple to twice by 2010 (Rideout, Foehr, & Roberts, 2010). This suggests that the gender difference in time spent playing video games is reducing. This reduction may be due to most computer games being designed for and marketed for boys ten years ago (e.g. Subrahmanyam & Greenfield, 1998; Gorriz & Medina, 2000). However, now some new games are being aimed at a female market and attract more female customers. Subrahmanyam and Greenfield (1998) found the game 'Barbie Fashion Designer' which was aimed at a female market had appealed to a large numbers of girls successfully. Some game designers have made efforts to tap into the female gamers' market by designing games for females such as "slapping the pink bow on 'Pacman'" (Cassell & Jenkins, 1998, p. 24). Moreover, electronic game play is becoming more and more popular for boys and girls, since this study showed 86% of children have 3 or more game systems in their home. Greater availability of game systems also means it is possible girls will spend more time on playing games.

When looking at the sample as a whole, this study further found that there were no clear trends about whether children preferred playing games with friends, elder people or on their own. From other UK studies, the results were also inconsistent. For example, Pratchett (2005) stated that young children (age 6-10) were the most sociable players and 54% of interviewed children said they preferred playing games with others rather than on their own. McFarlane, Sparrowhawk, and Heald (2002) also found that pupils are more likely to play games with one or more friends than on their own, while another study from the UK by Dawson, Cragg, Taylor, and Toombs (2007) proposed a different perspective. They indicated that gamers chose to play on their own or with others, depending on the different games. They explained that gamers often prefer to play games on their own because they can become immersed in the game without distractions. But sometimes they like to play together because it can be more fun with friends and they liked the “competitive ambience” (p.42) when playing sports games or multiplayer online games. However this different finding maybe arose because of the nature of the different samples. Dawson et al. (2007)’s research included a sample across a broader age spectrum, namely seven to 40 years, while the researcher’s study and work from Pratchett (2005) and McFarlane, Sparrowhawk, and Heald (2002)’s concentrated on primary students.

Another research finding related to children’s game interaction. Mitchell (1985) suggested that playing games was an important part of family play and electronic games brought the family members closer together for sharing game play and interaction. But recently, Fromme (2003) indicated that electronic games are more closely connected to peers than integrated into family interaction, and friends are the most important advisers and mediators for acquiring game information. The children are able to discuss the game with friends, to get help or advice, or share the feedback with each other, or compete with friends. The role of parents seems to be less important in children's gaming (Fromme, 2003). Dawson et al. (2007) also confirmed this finding that "gaming is an important talking point within peer groups" (p.10). These mixed results reflect the finding in this study that children report no clear preference about talking about games with peers, parents or other elder family members.

Although there were no clear overall patterns about children's preferences, this study did find significant gender differences in three areas. Girls were much more likely than boys to enjoy playing electronic games with other girls, more likely to talk to other girls about games than boys were, and more likely to report being taught by boys than boys themselves were. Maybe the result of girls were more likely playing with girls and talking with other girls is not surprising since from early childhood, boys and girls lean towards forming same-sex peer groups. Sex segregation among children has been discussed in many studies of children's group and friendship (e.g. Benenson, 1990, Thorne, 1992, Zosuls, Martin, Ruble, Miller, Gaertner, England, & Hill, 2011). However, there were some interesting facets of the present study which was at odds with this result. The results indicated no clear gender difference in electronic game playing with boys. Especially, girls were significantly more likely to report being taught by boys than boys themselves were. This is a new finding as there appears to be no published research that reports girls being taught by boys. One possible explanation, based on the findings of this study, could be that boys had significantly more positive attitudes towards electronic game playing, thus they will probably have more experiences, ideas, and game skills than girls. As a result, boys have more game-related information to teach girls, and the girls realise this. Further support for this explanation comes from a study by Fromme (2003) who stated that children like sharing game information with friends and Dawson et al. (2007) stated that boys shared their video game experiences and talked about video games more than girls. So it may be that when the girls play games with boys, they get game information from boys easier and perhaps the girls tend to see the boys as being the game 'experts'. This idea of boys as potential experts will be discussed further in Chapter Seven General Discussion.

As mentioned earlier, the most favourite game type for boys appeared to be simulations and action games as compared to girls who played more simulations and famous characters games. There has been research on gender differences in game preference since 1990s (e.g. Inkpen, et al., 1994; Kafai, 1996; Miller, Chaika, & Groppe, 1996; Subrahmanyam & Greenfield, 1998) and also some recent studies (e.g. Chou & Tsai, 2005; Sherry, Lucas, Greenberg, & Lachlan, 2006; Dawson, Cragg, Taylor & Toombs, 2007; Jenkins & Cassell, 2008; Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010; Procci, Bohnsack, & Bowers, 2011). However, there were no consistent findings when they reported children's favourite game type. For example, Fromme (2003) found action and fighting games were boys' favourite games and platform (Jump and run) games were girls' favourite games; McFarlane, Sparrowhawk, and Heald (2002) stated that the most popular games genre was adventure games for boys and girls; Griffith (1997) showed that the most frequently played game types for boys were role-play games and puzzle games for girls. Perhaps these differences were due to sampling differences, but it is possible that the differences are due to the following reasons. First, the methodology was different. Fomme (2003) asked the children to name their current favourite electronic games, which was the same as with the present study. In McFarlane et al. (2002)'s study, they asked the children to name three favourite games. However, Griffith (1997) asked children to choose which type of games they currently played from nine different categories. Second, because there is no standard categorisation of games and a variety of genres have increasingly come with more complex games (Kirriemuir & McFarlane, 2004), different studies used different game typologies. In the current study, the researcher fitted the games into appropriate categories in the Herz (1997) system which presented eight major categories: Action, Adventure, Fighting, Role-playing, Puzzle, Simulations, Sports and Strategy games. However, Fromme (2003) fits the games into a typology of computer games which was proposed by himself and his colleagues (Fromme, Meder, & Vollmer, 2000). This taxonomy includes seven categories: Platform (Jump and run), Action, Sport, Think and puzzle, Adventure, Racing and Simulation, strategy. Griffith (1997) listed 9 categories for children to choose: Sports simulations, Racers, Adventures, Puzzlers, Weird games, Platformers, Platform blasters, Beat 'em ups and Shoot 'em ups. McFarlane et al. (2002) did not mention clearly which game categories they used. This lack of an agreed categorization for games makes it very difficult to compare studies. Though there has been much attention in research to gender difference in game preference, the current study found there were still some games that can attract both boys and girls to play, such as 'Nintendogs', 'FIFA' or 'The Sims' etc. McFarlane, et al. (2002) found similar results in that the games 'Tomb Raider' or 'The Sims' were boys' and girls' favourite games. Moreover, McFarlane, et al. (2002) indicated that boys liked playing fighting games and some girls also enjoyed this kind of game. Therefore, it appears it is possible for boys and girls to enjoy playing the same games when using games in the classroom for supporting children's learning, and to identify a possible practical strategy for teachers to ease the difficulty of choosing different games to appeal to boys and girls together in the classroom.

The finding in this study that fun is the main reason for game playing is not surprising. There was a consistent finding identified by many researchers (e.g. Griffiths, 1997; Kirriemuir & Mcfarlane, 2004; Dawson, Cragg, Taylor, & Toombs, 2007; Olson, 2010) that children were motivated by the fun of the game. Besides this, the figures in this study in relation to items "defeat my friends" or "getting a high score" are below the midpoint of 50 on the scale, indicating a trend to disagree with the item. There are some studies that found that children were motivated by competition (e.g. Malone & Lepper, 1987; Subrahmanyam & Greenfield, 1998; Sanger, Willson, Davies, & Whittaker, 1997) or by challenge (e.g. Inkpen, et al., 1994; Lucas & sherry, 2004; Kirriemuir & Mcfarlane, 2004; Funk, Chan, Brouwer, & Curtiss, 2006) but in this study 'defeat my friends' (competition) or 'getting a high score' (challenge) seems not to appeal to the sample children. As stated by Greenberg et al. (2010), the children may draw more attention to the formal features of a game (e.g. completing the game) until about the age of 12. Thus for primary children, they may be less able to process plot features and become more interested in following complex storyline (Olson, 2010). So the children may be enjoying the feeling of winning the game and having fun through the game play. Moreover, this study only collected children's views for items "defeat my friends" or “getting a high score”, but the game software makes gamers want to win, to do better than they did last time, to get a high score, to get to the next level, and to complete the game. All these give players a feeling of competition and challenge.

In conclusion, this study explored Scottish primary school students’ game-playing characteristics: computer game playing time, preferred games, the social context of game use and game motivation. The results of this study do not give a complete picture of Scottish children's gaming culture, but may add some basic features to the growing body of knowledge about Scottish primary school children playing electronic games. This study led to a later cross-cultural phase looking at children of a similar age, in China, reported in section 4.3. However, the following section will describe another questionnaire which explored Scottish children’s mobile phone use and thoughts on mobile games.

**4.2 QUESTIONNAIRE TWO**

The second questionnaire was designed to investigate Scottish children’s views on playing mobile phone games and their use of mobile phones. In addition, because of the development of technology more game systems had been released and various games had been developed since the first questionnaire (the first questionnaire was conducted in 2006 and this questionnaire was in 2008), the researcher tried to find out more information about the game systems the children had engaged with, their favourite genre of games and why they like playing electronic games. See appendix B for a copy of this questionnaire. It should be noted here that the researcher used “mobile games” in this questionnaire to represent the games which are played on the mobile phone.

### 4.2.1 METHODOLOGY

The researcher will present the procedures for this questionnaire survey and all the methods of data collection and data analysis in this section.

#### 4.2.1.1 Participants

The participants were again a convenience sample. Because the teacher involved in the previous questionnaire had expressed interest in being involved further in the study, he was asked again. As he had changed class, this questionnaire involved the same teacher but not the same pupils. The participants for this questionnaire survey consisted of a total of 23 Scottish students (14 boys and 9 girls) aged around 11. One of the benefits of working with a similar age group to the previous study was that it provided a degree of consistency.

#### 4.2.1.2 Research instruments

The questionnaire consisted of fifteen items. The first to the twelfth questions concentrated on children’s attitudes towards mobiles and mobile games. The researcher then tried to get children’s opinions about electronic games, including games on all the game systems such as PC, Playstation, Xbox, Nintendo's, PSP, Gameboy, and mobiles from the remaining three questions.

The questionnaire involved four different question formats:

(1) Yes or No questions with follow up questions according to their answer. For example, children can choose Yes or No when asked whether they had a mobile phone. If they chose Yes then they needed to list their mobile phone model and answer a multiple-choice question about when they got their own mobile phone.

(2) Four questionnaire items were multiple-choice and single tick questions where children could tick only one option from specific choices. For example, children could choose one from the following three options when asked how often they play mobile games: everyday, at least once a week, once or twice a month. This type of question aimed to gather information about mobile ownership and children's usage of mobile phone games.

(3) Multiple tick questions, where children could choose as many options as they want. Five questions used this method to gain information on children's opinions about game systems they engaged in, favourite game types, the reasons for gaming, where they played mobile games and what they used mobile phones for. The questions of 'game systems children had engaged', 'favourite game types' and 'the reasons for gaming' were based on questionnaire one but modified a bit. For example, one question was asked to get the information about the game systems which children owned at home

in questionnaire one. However, children may not engage with some game systems which were owned at home, or maybe children play different game system owned by their friends. Moreover, more game systems had been released since questionnaire one was developed with the development of newer technology. As a result, the researcher asked children to tick the game systems which they had played before and fourteen choices were provided in this questionnaire, with one choice being “Other system” which allowed children to write down the system name to elaborate. In relation to the question about where the children normally played mobile games and what they used mobile phones for, the researcher listed three places for them to choose: at school, at home and in the bus/car, and listed six features/functions of mobile phones (e.g. make a call, send message, surf internet or play games). One choice was “Others” which allowed children to elaborate (See Appendix B for details).

#### 4.2.1.3 Procedure

The questionnaires were used in March 2008. They were handed out to the pupils and collected during regular class time by the researcher in the same manner as questionnaire one. The researcher had explained to students that the question items from one to twelve only concentrated on their views on mobiles, and the remaining three question items were about the electronic games included on all the game systems such as PC, Playstation, Xbox, Nintendo’s, PSP, Gameboy, and mobiles. All the data collected from the questionnaire was analysed by using the SPSS Version 14.0 statistical package. In order to investigate differences between boys and girls, the Chi-

Square test statistics method was used. The findings and the analysis are presented at 4.2.2 below.

4.2.2 FINDINGS

Twenty- three Scottish children, including 9 girls and 14 boys, completed the questionnaire. I now report findings of children's opinions on game systems they had engaged in, favourite game types and the reasons for gaming; and then the findings of children's opinions on mobile phones and mobile phone games will be addressed in this section.

**4.2.2.1 Electronic game systems children have engaged with**

Table 4.2.1 below summarises the game system children had engaged with in the Scottish sample.

Table 4.2.1: game systems engaged by the children in Scottish sample

| | Number of Children | % of Total | boy | girl |
|---|---|---|---|---|
| PC gaming | 21 | 91% | 13 | 8 |
| Playstation 2 | 20 | 87% | 14 | 6 |
| Xbox | 19 | 83% | 13 | 6 |
| Nintendo Wii | 18 | 78% | 10 | 8 |
| Mobile game | 18 | 78% | 11 | 7 |
| Game Boy | 17 | 74% | 11 | 6 |
| Nintendo DS Lite | 16 | 70% | 9 | 7 |
| Xbox 360 | 16 | 70% | 11 | 5 |
| Playstation | 16 | 70% | 11 | 5 |
| Playstation 3 | 14 | 61% | 10 | 4 |
| Nintendo DS | 13 | 57% | 8 | 5 |
| Nintendo GameCube | 12 | 52% | 10 | 2 |
| PSP | 11 | 48% | 9 | 2 |
| Other systems | 3 | 13% | 3 | 0 |

All children who were surveyed had played at least three game systems before and over fifty percent of children had played games on ten or more different game systems. The data indicated that children have a wide experience of different game systems and they do not all just play on one game system. It can be seen from Table 4.2.1 that PC gaming, Playsation2 and Xbox were the top three most popular game systems which the children in Scotland who were surveyed had played before. The PSP game system had been played with least frequently, with only 11 children playing it before.

Figure 4.2.1 shows the boys' and girls' responses to the game systems they have engaged with.

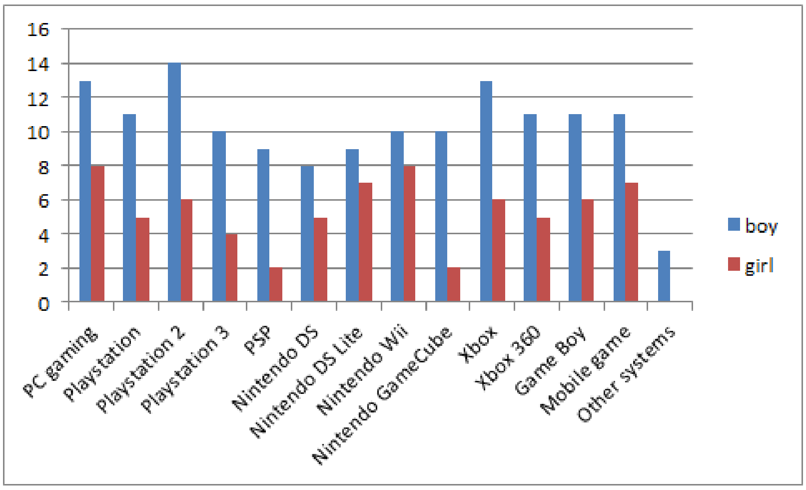


Figure 4.2.1: game systems played by the boys and girls in Scottish sample

It can be seen from Figure 4.2.1 that all the boys (14) had played games on Playstion2 and 13 of 14 boys had engaged with PC games and Xbox games. In contrast to the boys, nearly all the girls (eight of nine girls) had played games on Nintendo Wii and PC. The Nintendo DS Lite was another game system which more girls had engaged with. The findings indicated that boys and girls seemed to play games on a variety of game systems.

**4.2.2.2 Favourite type of electronic games**

The Table 4.2.2 below summarises children's favourite type of games in this Scottish sample.

Table 4.2.2: favourite game type by the children in Scottish sample

| | Number of Children | % of Total |
|---|---|---|
| Simulations games | 15 | 65% |
| Sports games | 14 | 61% |
| Action games | 12 | 52% |
| Adventure games | 11 | 48% |
| Fighting games | 11 | 48% |
| Puzzle games | 11 | 48% |
| Strategy games | 10 | 43% |
| Role-playing games | 9 | 39% |

It can be seen from the Table 4.2.2 that Simulations and Sports games were children's favourite games. Fifteen of the 23 children liked playing simulation games and 14 out of 23 children liked playing sports games. The least popular seemed to be role-playing games.

Figure 4.2.2 and Table 4.2.3 shows the boys' and girls' responses to their favourite game type.

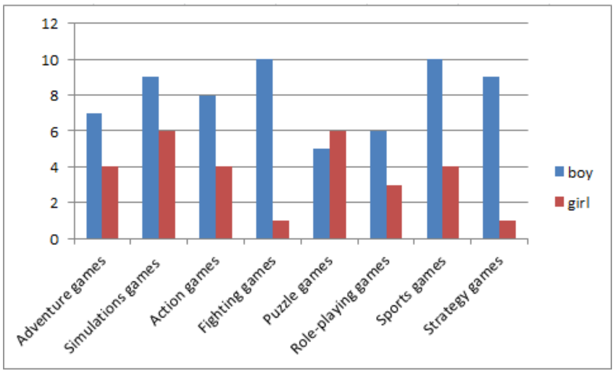


Figure 4.2.2: favourite game genre by the boys and girls in Scottish sample

Table 4.2.3: favourite game type by the boys and girls in Scottish sample

| Favourite game type | Gender | | Total |
|---|---|---|---|
| | boy (rank) | girl (rank) | |
| Sports games | 10 (1) | 4 (3) | 11 |
| Fighting games | 10 (1) | 1 (7) | 15 |
| Simulations games | 9 (3) | 6 (1) | 12 |
| Strategy games | 9 (3) | 1 (7) | 11 |
| Action games | 8 (5) | 4 (3) | 11 |
| Adventure games | 7 (6) | 4 (3) | 9 |
| Role-playing games | 6 (7) | 3 (6) | 14 |
| Puzzle games | 5 (8) | 6 (1) | 10 |
| Total | 64 | 29 | 93 |

In relation to the gender difference, Figure 4.2.2 showed that the favourite game types played by boys were fighting and sports games, but with girls, they were more likely to play simulations and puzzle games. When the children's favourite choices were ranked, male and female children appeared to be different in how they ranked puzzle games: boys ranked this type of game number in the last position, while females ranked it number one; similarly, fighting games were ranked number one among boys but were the joint least favourite for girls and strategy games were ranked number three among boys but were the joint least favourite for girls.

Though there seemed to be some differences between boys' and girls' favourite games, the differences in the boys' and girls' pattern of response were not statistically significant ($\chi^2$ (7, N = 23) = 8.16, p = .319) after conducting a Chi-square test. This means that boys and girls did not differ in their favourite game type.

### 4.2.2.3 Why children like playing electronic games

The Table 4.2.4 below summarises the data about why children like playing games.

Table 4.2.4: Why children like playing electronic game (Scottish sample)

| | Number of Children | % of Total |
|---|---|---|
| Because they are fun | 21 | 91% |
| Because I'd like to get a high score | 10 | 43% |
| Because they are exciting | 10 | 43% |
| Because I'd like to defeat my friends | 9 | 39% |
| Because I learn from them | 8 | 35% |

Table 4.2.4 indicates that children's top reasons for gameplay were that games were fun. Twenty-one out of 23 children (91%) reported that the reason they played games was because they were fun. Ten out of 23 children said the reason why they played digital games was that games were exciting and they'd like to get a high score. It also showed that the fact that they may learn from them is at the bottom of the list of reasons. Only eight children chose this option as their reason to play games. The data indicated that children seemed to be motivated by the fun and to a lesser extent by excitement, challenge (get a high score) and by the competitive elements (defeat friends). Learning from games did not seem to be a main motivating factor for these children.

Figure 4.2.3 and Table 4.2.5 showed the boys' and girls' responses as to why they like playing electronic games.

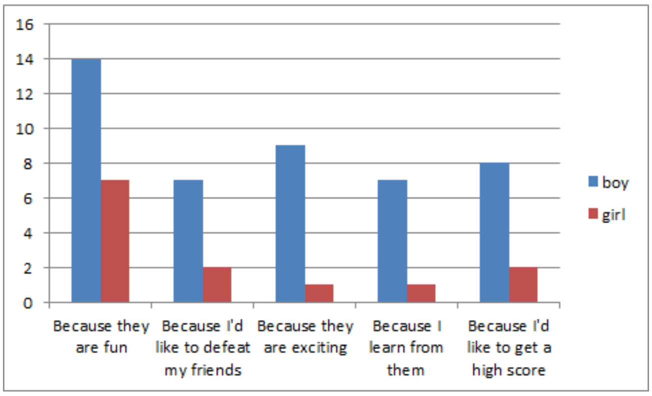


Figure 4.2.3: Why boys and girls like playing electronic game (Scottish sample)

Table 4.2.5: Why boys and girls like playing electronic game (Scottish sample)

| Favourite game type | Gender | | Total |
|---|---|---|---|
| | boy | girl | |
| Because they are fun | 14 | 7 | 21 |
| Because they are exciting | 9 | 1 | 10 |
| Because I'd like to get a high score | 8 | 2 | 10 |
| Because I learn from them | 7 | 1 | 8 |
| Because I'd like to defeat my friends | 7 | 2 | 9 |
| Total | 45 | 13 | 58 |

The results indicated that fun is the primary motive for game playing. In relation to the gender difference, it can be seen from Table 4.2.5, boys and girls were all motivated by the fun element of games.

The differences between boys' and girls' opinions were not statistically significant ($\chi^2$(4, N = 23) = 2.81, p = .59) after conducting a Chi-square test. Boys and girls did not differ in their views on the reason to play electronic games.

In summary, this section painted a picture of the children's views on the game systems they had played before, their preferred game type and motivations for game playing. These findings have covered some of the same things that were looked at in the first questionnaire. We will look at these two pictures together in the discussion section.

#### 4.2.2.4 Children's opinions on mobile phone games

The mobile phone was very common in the Scottish sample even at the age of 11, with 20 out of 23 having their own mobile phones. Most of them had owned their phones by age ten, and some had a phone from an even earlier age, when they were 8 or younger.

Fifteen children reported the brand and/or the model of their mobile phone. Five children wrote the brand and model of their mobile phone (e.g. Sony Ericsson1200, Samsung E370, Sony Ericsson W810i, Vodafone myc52, MotorolaV80). Ten children only wrote down the brand of their mobile phone (e.g. Samsung, Sony Ericsson, Nokia, Motorola, Philips). Some of the children's phones were quite expensive, for example, Sony Ericsson W810i cost around 100 pounds in 2008.

Over 95% (22 out of 23) of the sample children in Scotland have experience in playing mobile phone games. The Table 4.2.6 below summarises the name of mobile phone games that were played by boys and girls.

Table 4.2.6: The mobile phone games played by girls and boys (Scottish sample)

| Gender | The name of mobile phone games |
|---|---|
| girls and boys | Snake, Sudoku, Snowball, Sims, Fishy Fishee, FIFA, Mini golf, Kickball |
| girls | Snooker, Minesweeper, Pac-man, Snakes and Ladders, Mobile pets (Dogs, Cats), Brick, Tic-tac-toe, Bobby carrot |
| boys | Tetris, Bomb it, PES, LMA Manger, Penalties, Night pool club, Crash bandicoot, Pinball, Nibbler, Carrot hunt, Bounce, Tetris, Sponge bob, Prison Break, Escape the classroom, Hit the red button, Sonic, Space impact, Asteroid, Crazy |

From Table 4.2.6 it can be seen that the majority of mobile phone games played by the children in this survey were the internal games which were pre-installed onto the mobile phone, such as Snake, Snakes and Ladders, Minesweeper, Nibbler, Tetris, Bounce, Snooker, Sudoku, Snowball, Pin ball, Tic-tac-toe, Brick, Mini golf, Space impact and Asteroid.

The majority of surveyed children (18 out of 23) in Scotland played their mobile phones at home. However, there were 36% children who reported that they played games in the bus/car. Maybe because of school policy, no children chose to play mobile phone games at school.

15 of 22 children (eight boys and seven girls) have downloaded game content for their mobile phone and wrote down the names of mobile phone games which they had downloaded. Table 4.2.7 below summarises the name of mobile phone games that were downloaded by boys and girls.

Table 4.2.7: The mobile phone games downloaded by girls and boys (Scottish sample)

| Gender | The name of mobile games |
|---|---|
| girls and boys | FIFA |
| girls | Mobile pets (Dogs, Cats), Sims, Snowball, Golden balls, Snooker, Midnight snooker, Pac man |
| boys | PES,LMA Manager, Penalties, Crazy football, Snake 3, Nibbler, Crash bandicoot, Bomb it |

It can be seen from Table 4.2.7 that boys have downloaded football games (e.g. PES, Fifa, LMA Manager, Penalties and Crazy football,), game which need skills of controlling Key Arrows (Snake 3, Nibbler), driving game (e.g. Crash bandicoot) and puzzle game (Bomb it). The sports game was the most popular game downloaded by boys. Girls preferred to download Pets games (Mobile pets), snooker games (Snooker, Midnight snooker), a puzzle game (Golden balls) and keyboard skills games (Pac-man and Snowball). The Pets game was the most popular downloaded games for girls. One girl also mentioned that “Golden balls” which she downloaded cost her money to play every time. This was the only example of a child paying for playing her game from this questionnaire.

The Table 4.2.8 below summarises the categories the children were in with their responses according to how often they play mobile phone games.

Table 4.2.8: Frequency of mobile phone game playing of children from Scottish Sample

| | Everyday | At least once a week | Once or twice a month |
|---|---|---|---|
| Number of Children | 8 | 5 | 9 |
| % of Total | 36.3% | 22.7% | 41% |

It can be seen from Table 4.2.8 that the majority of the children did not play mobile phone games very often. 36.3% children played mobile phone games every day and nine out of 22 of students (41%) played once or twice a month. Though the sample children did not seem to play frequently, over half of them (59%) played mobile phone games at least once a week.

Figure 4.2.4 and Table 4.2.9 summarises the categories the boys and girls were in with their responses.

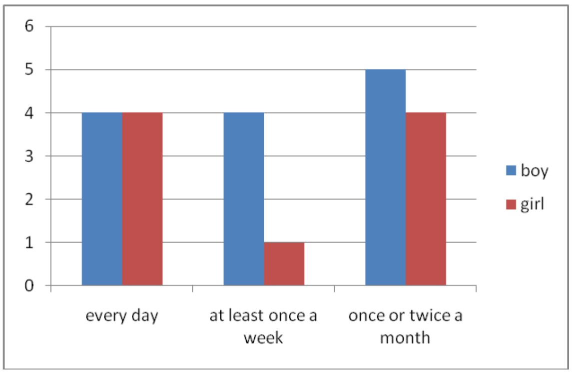


Figure 4.2.4: Frequency of mobile phone game playing of boys and girls from Scottish Sample

Table 4.2.9: Frequency of mobile phone game playing of boys and girls from Scottish Sample

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Frequency | everyday | 4 | 4 | 8 |
| | at least once a week | 4 | 1 | 5 |
| | once or twice a month | 5 | 4 | 9 |
| Total | | 13 | 9 | 22 |

It can be seen from Table 4.2.9 that four out of thirteen boys and four out of nine girls said they played mobile phone games every day. Five out of 11 boys and five out of nine girls played once or twice a month. In this case chi-square tests indicated that there was no statistically significant difference between boys and girls ($\chi^2$ (2, N = 23) = 1.224, p =.542).

Table 4.2.10 below summarises the categories the children were in with their responses according to – how long they play games per day.

Table 4.2.10: time spent on mobile phone games playing each day (Scottish Sample)

| | Under 10 minutes | 10 minutes to 30 minutes | 30 minutes to one hour | Over one hour |
|---|---|---|---|---|
| Number of Children | 11 | 7 | 2 | 2 |
| % of Total | 50% | 31.8% | 9.1% | 9.1% |

It can be seen from Table 4.2.10 that most pupils said they spent under ten minutes each day on mobile phone games playing. Only 9.1% children spent over one hour each day on mobile phone game playing.

Figure 4.2.5 and Table 4.2.11 (4×2 contingency table) showed the boys' and girls' responses separately in each category.

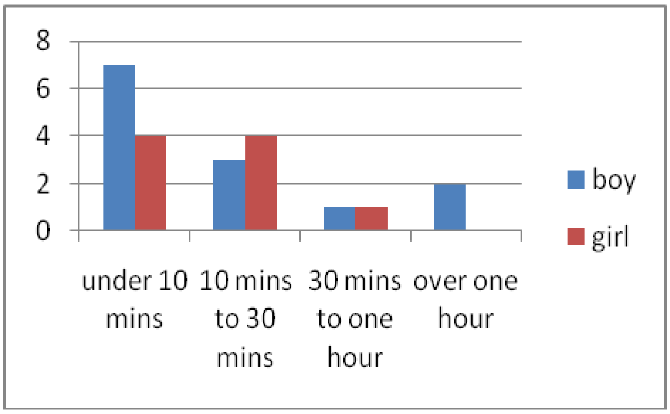


Figure 4.2.5: time spent on mobile phone games playing each day by boys and girls (Scottish Sample)

Table 4.2.11: time spent on mobile phone games playing each day by boys and girls (Scottish Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Time | Under 10 mins | 7 | 4 | 11 |
| | 10 mins to 30 mins | 3 | 4 | 7 |
| | 30 mins to one hour | 1 | 1 | 2 |
| | Over one hour | 2 | 0 | 2 |
| Total | | 13 | 9 | 22 |

Figure 4.2.5 showed there was more than triple the number of boys (10 boys) played mobile games under 30 minutes per day compared to only three boys who played mobile game over 30 minutes. Also, there was 8 times the amount of girls (eight girls) who played under 30 minutes compared to one girl played mobile game over 30 minutes. Only two boys reported that they spent one hour per day on mobile gaming. So, clearly the children did not play mobile game for long each day. Chi-squared tests also indicated that differences between boys and girls in this respect were not statistically significant. ($\chi^2$ (3, N = 23) = 2.31, p=.511)

The Table 4.2.12 below summarises the categories of children's attitudes towards playing mobile phone game.

Table 4.2.12: children's attitudes towards playing mobile phone game (Scottish Sample)

| | I do like playing mobile games | I sometimes like playing mobile games | I don't like playing mobile games |
|---|---|---|---|
| Number of Children | 8 | 13 | 1 |
| % of Total | 36.4% | 59.1% | 4.5% |

The data showed that children majority liked or sometimes liked playing mobile phone games. It can be seen from Table 4.2.13 that eight of 22 children (36.4%) said that they liked playing mobile phone games and 59.1% of children sometimes liked playing mobile phone games. Only one child reported that he did not like playing mobile phone games.

Figure 4.2.6 showed the boys' and girls' responses separately in each category and Table 4.2.13 summarised the chi-square statistic result (3×2 contingency tables).

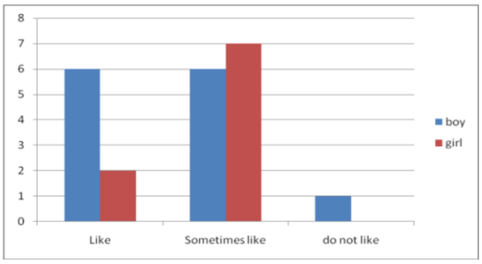


Figure 4.2.6: boys' and girls' attitudes towards playing mobile game (Scottish Sample)

Table 4.2.13: boys' and girls' attitudes towards playing mobile phone game (Scottish Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| attitude | like | 6 | 2 | 8 |
| | sometimes like | 6 | 7 | 13 |
| | don't like | 1 | 0 | 1 |
| Total | | 13 | 9 | 22 |

It can be seen there was a majority of boys and girls who reported that they sometimes liked playing mobile games. Six boys and two girls said they liked playing mobile games and only one boy didn't like playing mobile games. The chi-squared test indicated that there was no statistically significant difference between boys and girls. ($\chi^2$ (2, N = 23) = 2.43, p=.297)

Figure 4.2.7 below summarises which functions of mobile phones were used normally by the Scottish sample.

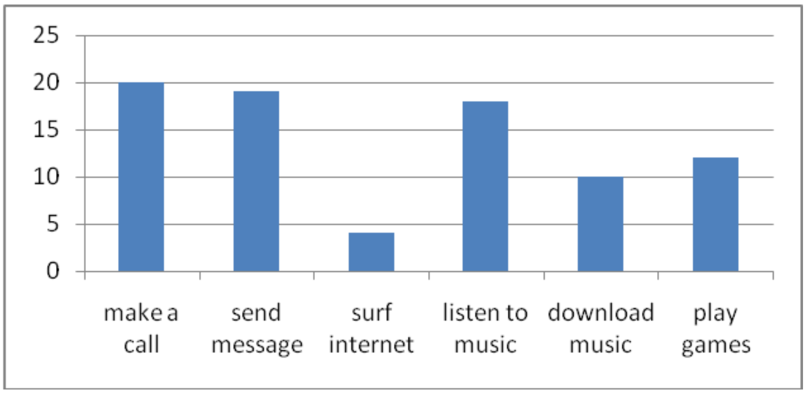


Figure 4.2.7: What do children use a mobile phone for (Scottish sample)

The majority of children in Scotland who were surveyed used mobile phones for making a call, sending a message and listening to music. Playing a mobile game was not a popular use of a mobile phone. Surfing the internet by using a mobile phone, storing pictures or videos, using the calculator and watching and using bluetooth and infrared from the mobile phones were other uses reported by children.

Figure 4.2.8 showed the boys' and girls' responses separately in each category.

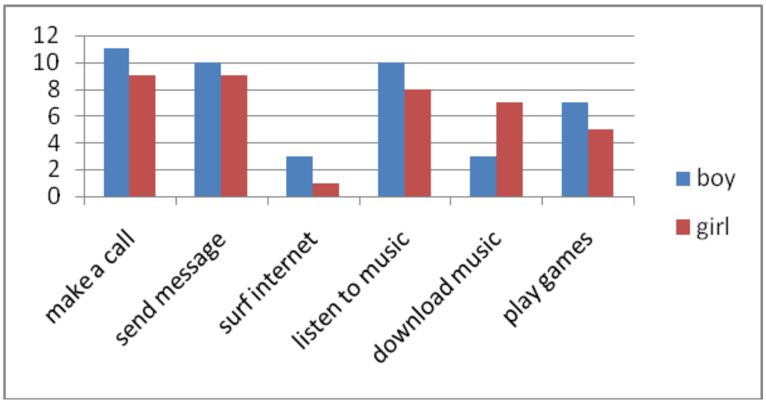


Figure 4.2.8: boys' and girls' responses on use of mobile phone (Scottish Sample)

It can be seen from Figure 4.2.8 that overall the boys' and girls' responses were very similar. The majority of boys and girls reported that they used mobile phones for making a call, sending a message and listening to music. However, there was an interesting facet that more girls (seven) downloaded music from their phones than boys (three). The chi-squared test indicated that there was no statistically significant difference between boys and girls. ($\chi^2$ (5, N = 23) = 1.56, p=.682). Boys and girls did not differ in their reasons for using mobiles.

## 4.2.3 DISCUSSION

The purpose of this questionnaire was to get more information about the game systems children have engaged with, their favourite genre of games and why they like playing electronic games. In addition, this study also examined Scottish primary students' characteristics in regard to their use of mobile phones and mobile phone games and their thoughts on playing games.

As described in 4.1.3, several studies have examined the differences between boys and girls in game type preferences (e.g. Inkpen, et al., 1994; Lucas & Sherry, 2004; Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010) and have concluded that boys and girls have different interests in the types of games. The current study seemed to show a different trend to previous studies. In this study, the differences between the boys’ and girls’ pattern of response were not statistically significant. This means that boys and girls did not differ in their favourite game type. The results from this study may reflect changing trends; perhaps boys and girls are changing their game preferences. Or it may be that Scottish school children are different. Moreover, the methodology that was used in this study is different from previous studies. This study asked children to choose which type of games they liked to play from eight different categories while the participants in Lucas and Sherry (2001)’s study were asked to choose from thirteen genres and 14 different video game genres in Greenberg, et.al (2010)’s research. In addition, the results may also be because of the small sample size in this study; there were only 23 children who participated in this questionnaire. However, previous studies such as Lucas and Sherry’s (2004) study, they have found a significant difference between males and females in the preferred game types after investigating 534 students’ opinions. Greenberg, Sherry, Lachlan, Lucas and Holmstrom (2010) did their investigation based on 1242 participants.

In addition, the students who participated in this study were primary students, but in Lucas and Sherry’s (2004) study they gathered the data from college students and Greenberg, et al. (2010) collected data from 5th-, 8th-, 11th-grade and university students. Lucas and Sherry~~’s~~ (2004) found a significant difference between males and females in eleven genres (strategy, puzzle, fantasy/role playing, action/adventure, sports, shooter, fighter, arcade, card/dice, quiz/trivia, and classic board games) from students' opinions on a total of thirteen genres, but not in racing/speed game and simulation game. Greenberg et.al. (2010) also found video game genre preferences were different between males and females, except for the 5th-grade students with the preference for imagination games (strategy, fantasy, and adventure genres). As discussed in questionnaire one, though there have been some different game interests for boys and girls, there were still some games that can attract both boys and girls to play.

Compared with questionnaire one, though a different method was used, a similar trend was found. 'Games are fun' was the strongest motivator for electronic game play among boys and girls. Twenty one of 23 children surveyed indicated that they were motivated by the fun factor. Learning from games did not seem to be a main motivating factor for the children. Maybe the children have not realized that they can learn from games. Skemp (2012) suggested that children were much more dedicated to an activity if children found that the activity has value and meaning to them. Therefore, if children knew they could learn from a game, a need for achieving 'the learning outcome' may motivate children to play more games. Empirical evidence exists that games can be effective tools for enhancing learning (e.g. Miller & Robertson, 2010; Squire, Barnett, Grant, & Higginbotham, 2004; Kirriemuir, 2002; Randel, Morris, Wetzel, & Whitehill, 1992). However there needs to be more studies and more evidence to support the belief that 'the learning outcome' can motivate children to play more electronic games, as claimed by Crawford (1984): "the fundamental motivation for all game-playing is to learn" (p.15).

The current study indicated that the majority of the children owned their mobile phones but the children did not play mobile phone games very often or for a long time, no matter whether boys or girls. Over 60 percent of the Scottish children did not play a mobile phone game every day and half of the pupils said they spent under 10 minutes on mobile phone games. The low percentages of game playing may be associated with the fact found in this study that the majority of mobile phone games played by children were the internal games which were pre-installed onto the mobile phone. The pre-installed games may not attract children because the pre-installed games were not intended for children. In addition, the small screen, low speed processor and memory may also affect the mobile phone game playing, thus the children will not spend much time on mobile phone gaming.

The majority of the sample Scottish children only used their mobile phone for making a call, sending a message and listening to music. This finding was supported by findings from a recent Ofcm (2012) report which conducted 1,717 in-home interviews with parents and children aged 5-15 and found that the most popular uses for children were sending text messages and making calls. Playing mobile phone games was only the third most popular use. Moreover, as stated in this questionnaire, children have 14 different games systems to choose to play games and more game systems will be released with the rapid development of the game industry, so the time spent on mobile phones may remain limited. Mobile games received a burst of attention with strong consumer demand since the release of iphone by Apple in 2009 (Entertainment Software Association, 2011). However, this second questionnaire was conducted in the early 2008 and mobile phone games were not as sophisticated as they have become.

Although the time children spent on playing mobile phone games was limited, the data showed that over half of them played mobile phone games at least once a week and most children liked or sometimes liked playing mobile phone games. The fact that children have positive attitude towards mobile phone games suggests that we could explore ways in which they might be used for educational purposes.

In conclusion, this study indicated that these children were quite familiar with mobile phones and had positive attitudes towards mobile phone games. The previous studies (e.g. Moreno, 2002; Orvis, Orvis, Belanich & Mullin, 2007) which investigated the effects of instructional games on learning have indicated that students with prior computer skills or electronic game experience will have less difficulty in playing games and perform better. These factors, and others, led to a later phase of a study using mobile phone games for supporting children's mathematics learning, reported in Chapter Five. However, the following section will describe another questionnaire which explored Chinese children's thoughts on electronic games and mobile phone games.

## 4.3 QUESTIONNAIRE THREE

As mentioned in Chapter three, section 3.2, in order to find out children's views on game playing, in Scotland and China, this questionnaire was designed to explore Chinese children's attitudes towards electronic games and opinions about mobile games. See appendix C for a copy of this questionnaire.

4.3.1 METHODOLOGY

The researcher will present the procedures and the methods which were used to conduct the data collection and data analysis of this questionnaire in this section.

**4.3.1.1 Participants**

Once more the participants were a convenience sample. Because the research targeted primary school students in China, and the researcher has two contacts who worked in primary schools in China, the researcher sent the requests to these two teachers. These two teachers from different primary schools were happy to support. One teacher was a P4 (age 10-11) class teacher in an urban city primary school and the other was a P1 (age 6-7) class teacher in a rural primary school. Considering the age of the Scottish participants, with questionnaire one and two, I wanted to choose Chinese children aged around 11 years as my sample. With the help of the P1 class teacher, a P4 class teacher from the same primary school was happy to participate.

This urban primary school was located in south part of China and was a famous primary school and had a good reputation in that city. The students in this school were primarily middle class. The rural school was situated in a county but in the same province as the urban primary school. The students in this school were primarily from the countryside and low-socioeconomic-status homes. The participants for this questionnaire survey consisted of a total of 127 Chinese pupils (52 students from urban school and 75 from rural school) aged from 9 to 11.

#### 4.3.1.2 Research instruments

The questionnaire used to investigate the Chinese children's view on electronic games and mobile games was initially constructed by combining questionnaire one and questionnaire two (from the Scottish surveys) together. The developed questionnaire was sent to two class teachers by email after being translated into Chinese by the researcher. But the feedback from the two class teachers was that the questionnaire was too long and too time-consuming. Class teachers in China have a tight timetable and could not give the researcher much time to conduct the questionnaire. Therefore the researcher decided to design a new questionnaire for Chinese pupils, but still based on the previous two questionnaires.

Before designing the new questionnaire, I contacted the two class teachers separately by phone in order to get more ideas from them and told them the purpose and the procedure of this study again, although I had previously sent them emails about it. The two class teachers suggested that the questionnaire should be quick to answer because they didn't have much time. They suggested that most of their students didn't have their own mobile phones and children couldn't take phones to school because of the strict school policy, so there should not be many questions on mobile phones and mobile phone games playing. Moreover, one of teachers suggested to me that it would be better to change the four options of time commitment for games playing: Under 30 minutes, 30 minutes to one hour, One to two hours, Over two hours, because the majority of children in her class will not spend over one hour on games playing, based on her experience.

So, according to the suggestion of the two teachers, the questionnaire had to be finished by children within a limited time, and all the questions had to be easy to answer. Therefore, a 5-point Likert scale was used to assess the participants' attitudes this time. The Likert technique (Likert, 1932) is one of the most popular measuring tools used to measure attitudes, beliefs, preferences, and behaviours or affective reactions (e.g. Cohen, Manion & Morrison, 2007) and is widely used in education research for measuring attitudes (Gay & Airasian, 2000). A Likert scale comprises a series of statements, and respondents are required to select the specified category that is most suitable for their opinion. This involves agreement or disagreement with each statement. A 5-point Likert scale is a common scale and participants are asked to indicate whether they strongly disagree, disagree, neither agree nor disagree, agree or strongly agree. Each point of the five-point scale is given a numerical value from one to five. Therefore a total numerical value can be calculated from all the responses to measure the attitudes. A 5-point Likert scale was used in this questionnaire, but some categories are ordered from "like a lot" to "dislike a lot" instead of the traditional "Strongly disagree" to "Strongly agree" response continuum, because the response categories would be more meaningful to the respondents. For example, the participants were asked to choose whether they like a lot, like, neither like nor dislike, dislike, dislike a lot playing electronic games. At the marking stage, the score is marked from 1 to 5. A higher score reflects a higher level of agreement with each item and lower scores reflect participants' disagreement with each item asked.

The final questionnaire consisted of twenty-three items, one item included three sub-items, so the total number of items in this questionnaire was 25. Among these twenty-five items, there were 17 items in relation to children's electronic game use pattern and their attitudes towards electronic game playing, three questions to find out children's opinions about educational games designed for educational purposes in addition to entertainment value and 5 items about children's use of mobile phone and mobile phone games. In this questionnaire, twenty items were originally from questionnaires one or two, and modified by using a 5-point Likert scale instead of a continuous rating scale, or other minor modifications. For example, the question 'How long do you normally play for per day?' was originally from questionnaire one. But, based on the teacher's suggestion and in order to get a clearer pictures of children's time commitment on game playing, four options were changed from 'Under 30 minutes, 30 minutes to one hour, One to two hours, Over two hours' to 'Under 10 minutes, 10 minutes to 30 minutes, 30 minutes to one hour, Over one hour'. The remaining six items were designed to get information about whether children played electronic games before, whether they have brothers or sisters, where they played electronic games normally and their opinions about educational games. See appendix C for more details of this questionnaire.

All questions were constructed in Chinese. This questionnaire involved many different question formats:

(1) The researcher adopted a multiple-choice method as for questionnaire one and two.

a. Single tick questions: there were fourteen items in which children were asked to select only one option from a list. These questions tried to investigate children's play pattern on electronic games and children's attitudes by using 5-point Likert scale. For example, students were asked how often they played electronic games. Pupils could choose from the following options: Everyday, At least once a week, Once or twice a month.

b. Multiple tick questions: two question items asked children to select one or more of the choices from a list. These questions tried to find out children's opinions about their favourite game types and the reasons for gaming.

(2) Yes or No questions and some with follow up questions according to their answer. There were eight questions. For example: Children could choose Yes or No when they answered whether they had played electronic games before. Or children could choose Yes or No when asked whether they played educational games before. This question was followed by a question to list the educational games which they played.

(3) Free text question: Only one item in this questionnaire, which referred to the favourite games of the children, used this method.

#### 4.3.1.3 Procedure

The questionnaires were used in April 2008 and were handed out to the pupils and collected during regular class time, on different days (one week difference) in two primary schools by the researcher. If children did not understand they were helped by the teacher or the researcher. The questionnaire took around 10 minutes to complete in the two classes and the researcher took the questionnaires away at the end. All the data were coded and analysed by using the SPSS Version 14.0 statistical package.

The researcher changed the Likert scale points from 1 to 5 when analysing the data. In order to investigate differences on the basis of gender, Chi-Square test and t-test statistics methods were used. Chi-square test was used to compare the patterns of responses to the multiple choice questions and T-test was used to look for any difference in the mean scores of boys' and girls' responses on the Likert scale items.

The findings and the results of these analyses are presented in the results section at 4.3.2 below.

### 4.3.2 FINDINGS

The participants for this questionnaire survey consisted of a total of 127 Chinese pupils aged from 9 to 11. One hundred and nine of the 127 (85.8%) children (70 boys and 39 girls) replied that they had played electronic games before. So the findings below will be based on the analysis of these 109 students. There were 7.7% (4 out of 52) children from the urban school and 18.7% (14 out of 75) children from the rural school who had not played electronic games before.

This section will be divided into four parts. The first part will report the findings on children's game use. Then the children's attitudes towards game playing will be described. The results of children's views on educational games will be put afterwards.

The findings about children's ownership of mobile phones and their opinions on mobile phone games will be presented at the end.

### 4.3.2.1 Chinese children's game use

This section will report the findings about the frequency of children's game playing, the times when they play games at home and time spent on games playing each day and where they normally play electronic games.

4.3.2.1.1 Frequency of game playing of children from Chinese Sample

Table 4.3.1 summarises the categories the children were in with their responses according to how often they played games.

Table 4.3.1: Frequency of game playing of children from Chinese Sample

| | Everyday | At least once a week | Once or twice a month |
|---|---|---|---|
| Number of Children | 4 | 61 | 44 |
| % of Total | 3.7% | 56% | 40.3% |

It can be seen from Table 4.3.1 that the majority of surveyed children in China played games at least once a week. Over one-third of Chinese children played games once or twice a month. Only four of 109 Chinese children (3.7%) played everyday.

Figure 4.3.1 and Table 4.3.2 summarise the numbers of the boys and girls in each category of frequency of game playing.

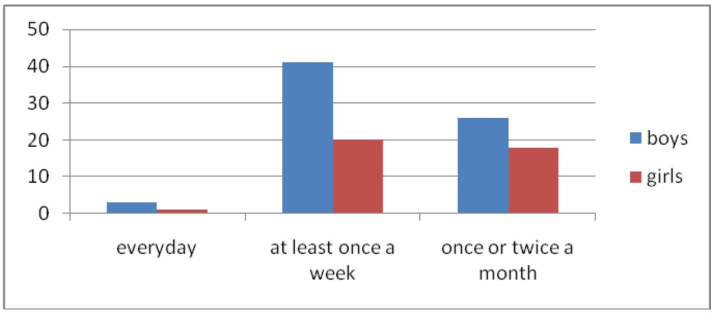


Figure 4.3.1: Frequency of game playing of boys and girls from Chinese Sample

Table 4.3.2: Frequency of game playing of boys and girls from Chinese Sample

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Frequency | everyday | 3 | 1 | 4 |
| | at least once a week | 41 | 20 | 61 |
| | once or twice a month | 26 | 18 | 44 |
| Total | | 70 | 39 | 109 |

It can be seen from Figure 4.3.2 that over fifty percent of Chinese children of both genders said they played games at least once a week. Forty percent of girls and boys played games only once or twice a month. These results indicate that Chinese children seemed not to be playing games very often, no matter whether boys or girls. In order to see whether any difference between boys and girls was statistically significant, Chi-square test (3x2 contingency tables) was used to compare the frequencies of boys' and girls' responses. In this case chi-square tests indicated that there was no significant difference between boys and girls ($\chi^2$ (2, N = 109) = 0.94, p = .624).

4.3.2.1.2 When do children play games at home? (Chinese Sample)

The Table 4.3.3 summarised the categories the children were in with their responses according to when they play games.

Table 4.3.3: the times when pupils play computer games at home (Chinese Sample)

| | Mostly on weekends | Mostly on weekdays | All the time |
|---|---|---|---|
| Number of Children | 102 | 3 | 4 |
| % of Total | 93.6% | 2.8% | 3.6% |

The data showed that more than ninety percent (102 of 109) of all children said that they played electronic games on weekends at home.

Figure 4.3.2 shows the boys' and girls' responses separately in each category and Table 4.3.4 summarises the chi-square statistic result ($3 \times 2$ contingency tables).

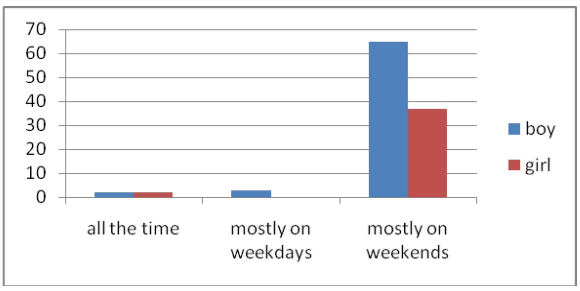


Figure 4.3.2: the times when boys and girls play computer games at home (Chinese Sample)

Table 4.3.4: the times when boys and girls play computer games at home (Chinese Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Time | all the time | 2 | 2 | 4 |
| | mostly on weekdays | 3 | 0 | 3 |
| | mostly on weekends | 65 | 37 | 102 |
| Total | | 70 | 39 | 109 |

It can be seen from Figure 4.3.2 that there was a majority of boys and girls who reported that they played games mostly on weekends at home, and only two boys and two girls said they played games all the time. The chi-squared test indicated there was no significant difference between boys and girls ($\chi^2$ (2, N = 109) = 2.03, p = .362).

4.3.2.1.3 How long do children play games in a day

The Table 4.3.5 below showed the categories the children were in with their responses according to how long they play games in a day.

Table 4.3.5: time spent on games playing in a day (Chinese Sample)

| | Under 10 minutes | 10 minutes to 30 minutes | 30 minutes to one hour | Over one hour |
|---|---|---|---|---|
| Number of Children | 19 | 44 | 35 | 11 |
| % of Total | 17.4% | 40.4% | 32.1% | 10.1% |

It can be seen from Table 4.3.5 that the majority of Chinese pupils (79 of 109) spent 10 minutes to one hour on games playing in a day that they played a game.

Figure 4.3.3 and Table 4.3.6 (4×2 contingency tables) showed the boys' and girls' responses in each category.

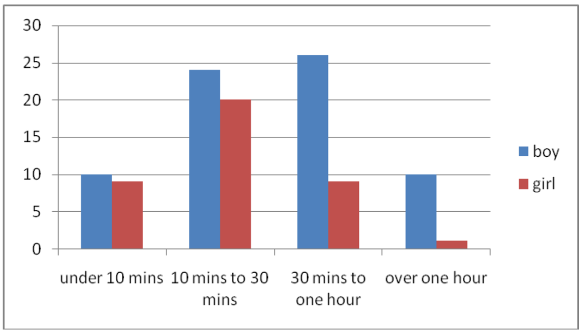


Figure 4.3.3: time spent on games playing in a day by boys and girls (Chinese Sample)

Table 4.3.6: time spent on games playing in a day by boys and girls (Chinese Sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Time | Over one hour | 10 | 1 | 11 |
| | 30 mins to one hour | 26 | 9 | 35 |
| | 10 mins to 30 mins | 24 | 20 | 44 |
| | Under 10 mins | 10 | 9 | 19 |
| Total | | 70 | 39 | 109 |

The data indicates that boys spent more time on games than girls. The Figure 4.3.3 showed that over half of boys reported that they spent over 30 minutes in a day on gaming while over half of the girls reported that they spent 10 minutes to 30 minutes. Ten times the number of boys (10 boys) were playing games over one hour each time compared to the girls (1 girl). Also there were more boys (26 boys) playing for 30 minutes to one hour a day compared to girls (9 girls). The Chi-square results confirmed that there was a significant difference between boys and girls ($\chi^2(3, N = 109) = 7.85$, $p<.05$). This finding indicated that boys reported spending significantly more time on playing games than girls.

4.3.2.1.4 Where do they normally play games?

Table 4.3.7 below summarises the categories the children were in with their responses according to - where do they normally play game.

Table 4.3.7: the place where children played the electronic game (Chinese Sample)

| | at home | at school | at internet cafe |
|---|---|---|---|
| Number of Children | 68 | 38 | 3 |
| % of Total | 62.4% | 34.9% | 2.7% |

It can be seen from Table 4.3.7 that the majority of surveyed children (62.4%) in China played electronic games at home. However, there were also a sizeable proportion of Chinese children (34.9%) who played games at school. An Internet cafe was not a usual place for Chinese children to play electronic games.

Figure 4.3.4 and Table 4.3.8 below summarised the categories the boys and girls were in with their responses for the place where they normally played electronic games.

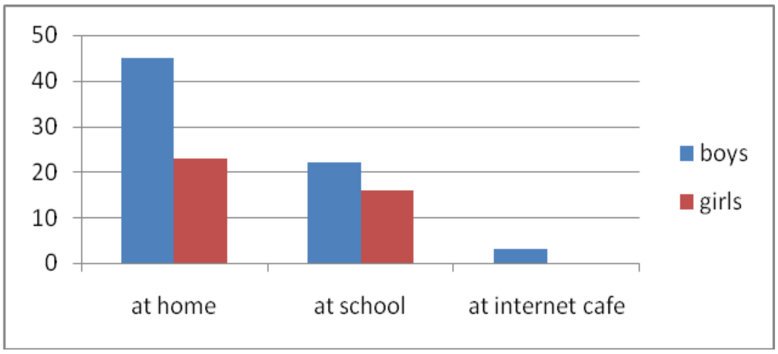


Figure 4.3.4: the place where boys and girls played electronic games (Chinese sample)

Table 4.3.8: the place where boys and girls played electronic games (Chinese sample)

| | | Gender | | Total |
|---|---|---|---|---|
| | | boy | girl | |
| Place | at home | 45 | 23 | 68 |
| | at school | 22 | 16 | 38 |
| | at internet cafe | 3 | 0 | 3 |
| Total | | 70 | 39 | 109 |

It can be seen from the Figure 4.3.4 that over fifty percent of boys (45 of 70) and girls (23 of 39) played games at home. Playing games at school was also popular for some boys (22 of 70) and girls (16 of 39). No girls played games at an internet cafe.

In order to see whether any difference between boys and girls was statistically significant the data were investigated using the Chi-square statistic (3x2 contingency tables). In this case chi-square tests indicated that there was no significant difference between boys and girls. ($\chi^2$(2, N = 109) = 2.45, p=.294)

#### 4.3.2.2 Chinese children's views on game playing

This section will describe the findings of Chinese children's attitudes toward game playing, playing games alone, playing games with parents, with friends, and with brothers/sisters. All these questions employed a 5-point Likert scale. As described earlier, the researcher had given a numerical value to the category 'like a lot', 'like', 'neither like nor dislike', 'dislike' or 'dislike a lot' from five to one. The difference between boys and girls will also be examined by using an independent-sample t-test which was used to compare the mean score of boys and girls and to determine whether any differences were statistically significant.

This section will also look at the children's preferences in relation to playing with boys or girls, the children's views on possible situations in which they tend to play electronic games, their favourite genre of electronic games, why they like playing games and children's view about their parents' attitudes towards their game playing.

4.3.2.2.1 Do you like playing electronic games?

Mean scores for all the children and boys' and girls' opinions towards electronic games playing were calculated and shown in table 4.3.9. An independent-samples t-test was also conducted to compare the mean scores for each item to see whether any differences were statistically significant.

Table 4.3.9: mean scores of overall and boys' and girls' response (Chinese Sample)

| Question | Overall Mean (SD) | Girls' Mean (SD) | Boys' Mean (SD) | t | Sig. |
|---|---|---|---|---|---|
| Do you like playing electronic games? | 3.72 (.89) | 3.67 (.90) | 3.74 (.90) | .425 | .672 |

It can be seen from table 4.3.9 that the overall mean indicated that Chinese children tended to like playing electronic games because the mean scores were towards the positive end of the scale and the mean score of boys and girls were very similar.

The t-test showed the differences between boys and girls were not significant (p>.05). This means that boys and girls did not differ in their views on this item.

4.3.2.2.2 Who do children like playing game with?

Table 4.3.10 presents the mean scores for children's response to who they like playing electronic game with. An independent-samples t-test was used to compare the difference in mean scores.

Table 4.3.10: mean scores in relation to who children like to play games with (Chinese Sample)

| Statement | Overall Mean(SD) | Girls' Mean(SD) | Boys' Mean(SD) | t | Sig. |
|---|---|---|---|---|---|
| I like playing electronic games alone. | 3.54 (.977) | 3.56 (.995) | 3.53 (.974) | -.181 | .857 |
| I like playing electronic games with parents. | 3.17 (1.085) | 3.23 (.902) | 3.13 (1.179) | -.507 | .614 |
| I like playing electronic games with brothers or sisters. | 3.61 (1.036) | 3.38 (.990) | 3.74 (1.045) | 1.748 | .083 |
| I like playing electronic games with friends. | 3.95 (.937) | 3.87 (.923) | 4.00 (.948) | .683 | .496 |

In general, it can be seen from table 4.3.10 that there was a range of overall mean score from (M = 3.95, SD = 0.937) for the item ‘I like playing electronic games with friends’ to (M = 3.17, SD = 1.085) for the item ‘I like playing electronic games with parents’. The figures indicated that children seemed to be more likely to like playing with friends. Boys’ and girls’ scores appeared to be similar on all items.

The t-test showed the differences between boys and girls were not significant ($p>.05$). This means that boys and girls did not differ in their views on these four items.

4.3.2.2.3 Preference of playing with boys or girls

The Table 4.3.11 showed Chinese boys’ and girls’ preference game playing group.

Table 4.3.11: boys’ and girls’ response to their preference game playing group (Chinese Sample)

| | Gender | | Total |
|---|---|---|---|
| | boy | girl | |
| Prefer playing with boys | 68 | 2 | 70 |
| Prefer playing with girls | 2 | 37 | 39 |
| Total | 70 | 39 | 109 |

As shown in the Table 4.3.11, the data indicated that the children’s preference group was the peer group of the same gender. Boys preferred to play with other boys, and girls most often played together with other girls. Chi-squared tests indicated that differences between boys and girls in this respect were significant ($\chi^2(1, N = 109) = 92.29, p<.05$).

4.3.2.2.4 Possible situations in which children tend to play electronic games

The Table 4.3.12 showed the categories of children's response to possible situations in which they tend to play games.

Table 4.3.12: Children's response to possible situations in which they tend to play electronic games (Chinese Sample)

| Possible situations | Number of Children | % of Total |
|---|---|---|
| I don't want to do my homework. | 2 | 1.8% |
| Friends come to my home and I play electronic games with them. | 25 | 22.9% |
| I play electronic games when I am bored. | 81 | 74.3% |
| I play electronic games as often as possible. | 1 | 1% |

In general, it can be seen from table 4.3.12 that the majority of Chinese pupils (81 of 109) tended to play electronic games when they were bored.

Figure 4.3.5 and Table 4.3.13 (4×2 contingency tables) showed the boys' and girls' responses in each category.

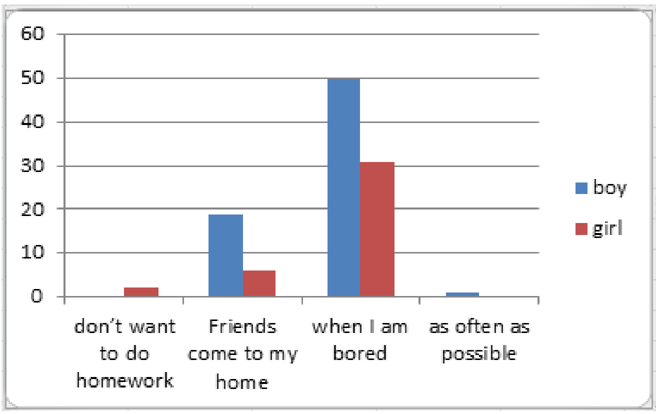


Figure 4.3.5: Boys' and girls' response to possible situations in which they tend to play electronic games (Chinese Sample)

Table 4.3.13: Boys' and girls' response to possible situations in which they tend to play electronic games (Chinese Sample)

| Possible situations | Gender | | Total |
|---|---|---|---|
| | boy | girl | |
| I don't want to do my homework. | 0 | 2 | 2 |
| Friends come to my home and I play electronic games with them. | 19 | 6 | 25 |
| I play electronic games when I am bored. | 50 | 31 | 81 |
| I play electronic games as often as possible. | 1 | 0 | 1 |
| Total | 70 | 39 | 109 |

It can be seen from the Figure 4.3.5 that the majority of boys (50 of 70) and the majority of girls (31 of 39) said that when they feel bored they played electronic games. Only two girls chose the reason that they didn't want to do their homework and one boy reported that he tended to play games as often as possible. The chi-squared test indicated there was no significant difference between boys and girls ($\chi^2$ (3, N = 109) = 5.88, p = .118).

4.3.2.2.5 Why children like playing electronic games

Table 4.3.14 below summarises the children's response of why children like playing electronic game (Chinese Sample).

Table 4.3.14: Children' response to the reason of why they like playing electronic games (Chinese Sample)

| Reasons | Number of Children | % of Total |
|---|---|---|
| because the electronic games are fun | 50 | 45.9% |
| because I learn from the electronic games | 38 | 34.9% |
| because the electronic games are exciting | 36 | 33% |
| because I want to defeat my friends | 9 | 8.3% |
| because I want to get a high score | 22 | 20.2% |

It should be noted that the percentage figures add up to more than 100% because children were able to give more than one reason. Table 4.3.14 shows that the majority of children reported they played electronic games because they are fun. Learning from games is the second most popular choice for Chinese children to motivate them playing. Besides these two options, over one-third of children were also likely to be motivated by exciting games and around one-fifth of children were motivated by getting a high score. Only nine children indicated they'd like to defeat their friends. The data indicated that children seemed to be motivated by fun most and the competition factor (defeat friends) is the least motivating factor for the Chinese children.

Figure 4.3.6 and Table 4.3.15 (5×2 contingency tables) showed the boys' and girls' responses in each category.

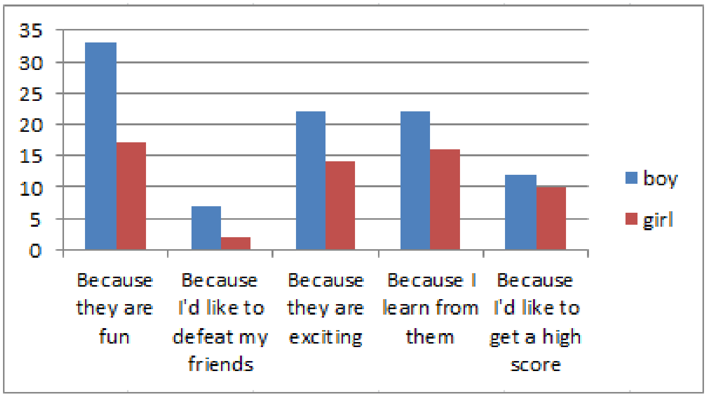


Figure 4.3.6: Why boys and girls like playing electronic games (Chinese sample)

Table 4.3.15: Why boys and girls like playing electronic games (Chinese sample)

| Reasons | Gender | | Total |
|---|---|---|---|
| | boy | girl | |
| because electronic games are fun | 33 | 17 | 50 |
| because I want to defeat my friends | 7 | 2 | 9 |
| because the electronic games are exciting | 22 | 14 | 36 |
| because I learn from the electronic games | 22 | 16 | 38 |
| because I want to get a high score | 12 | 10 | 22 |
| Total | 96 | 59 | 155 |

The chi-squared test indicated there was no significant difference between boys and girls ($\chi^2$ (4, N = 109) = 2.09, p = .719).

4.3.2.2.6 Children's views about whether electronic games help learning

21.8% (24 of 109) children in this study reported that electronic games had helped their learning. The rest of the children thought games had not helped them learn.

4.3.2.2.7 Favourite electronic games

The Table 4.3.16 below summarises children's favourite type of games in the Chinese sample.

Table 4.3.16: Favourite game genre by the children in the Chinese sample

| | Number of Children | % of Total |
|---|---|---|
| Adventure games | 65 | 60% |
| Puzzle games | 56 | 51% |
| Fighting games | 28 | 26% |
| Strategy games | 28 | 26% |
| Action games | 23 | 21% |
| Role-playing games | 21 | 19% |
| Sports games | 21 | 19% |
| Simulations games | 16 | 15% |

It can be seen from the Table 4.3.16 that Adventure and Puzzle games were the children's most favourite games. Sixty-five out of 109 children liked playing Adventure games and 56 out of 109 children liked playing Puzzle game. The least popular seemed to be simulations games.

Table 4.3.17: Favourite game type by the boys and girls in Chinese sample

| Favourite game type | Gender | | Total |
|---|---|---|---|
| | boy (rank) | Girl (rank) | |
| Adventure games | 48 (1) | 17 (2) | 65 |
| Puzzle games | 30 (2) | 26 (1) | 56 |
| Strategy games | 28 (3) | 0 (8) | 28 |
| Fighting games | 27 (4) | 1 (7) | 28 |
| Action games | 18 (5) | 5 (6) | 23 |
| Sports games | 15 (6) | 6 (5) | 21 |
| Simulations games | 9 (7) | 7 (4) | 16 |
| Role-playing games | 6 (8) | 15 (3) | 21 |
| Total | 181 | 77 | 258 |

In relation to the gender difference, it can be seen from the Table 4.3.17 that the favourite game types played by boys and girls were adventure and puzzle games. When the children's favourite choices were ranked, a pattern was evident. Girls did not like playing fighting and strategy games, but boys ranked strategy games number three and fighting games number four. Moreover, simulation and role-playing games were the least two favourite for boys but girls ranked role-playing games number three and simulation games number four. When a chi-squared test was conducted on the data the differences were significant ($\chi^2$ (7, N = 109) = 48.48, p = .00). We can therefore be confident that these boys and girls do have different game preferences.

Besides asking children to choose their favourite game type, this questionnaire also asked the children to describe their favourite electronic games. Ninety-two out of 109 children responded to this question and most of them wrote down a short description of their favourite game (e.g. car racing, shooting, fighting, the game is fun or exciting, a game which can help me learn, dressing up game, this game should be difficult, the game will have beautiful frame and scene). Some wrote down the type of game (e.g. puzzle games, adventure game, strategy game or fighting game) and the others wrote the name of their favourite game (e.g. Super Mario, The King of Fighters, PopKart). Over sixty percent of children stated that they favour playing puzzle games or a game which could help improve academic performance.

The girls reported various favourite games, such as they liked the game with a beautiful frame or with a lovely character in the game. They also showed interest in the game which can help them learn or become smarter. Beauty games (e.g. make up, dress up), racing games, adventure games or some simulation games (e.g. drawing, cooking) were also girls' favourites. Boys showed similar interests to girls in that they liked playing puzzle games which can help learning or racing games. Moreover, boys tended to prefer playing shooting and fighting games.

After trying to fit into the appropriate categories according to the Herz (1997) system (also described in former section 4.1.2.3.8), Chinese boys favoured fighting, puzzle, adventure and sport games more. Chinese girls preferred puzzle, adventure and role-playing games more.

4.3.2.2.8 Children's view about their parents' attitudes towards their game playing

Table 4.3.18 summarises views about their parents' attitudes towards their game playing.

Table 4.3.18 children's view about their parents' attitudes towards their game playing (Chinese Sample)

| | Strongly agree | agree | neither agree nor disagree | disagree | Strongly disagree | Total |
|---|---|---|---|---|---|---|
| Number of Children | 5 | 19 | 71 | 12 | 2 | 109 |
| % of Total | 4.6% | 17.4% | 65.1% | 11% | 1.8% | 100% |

Over 65% of Chinese children thought their parents had neutral attitudes (neither disagree nor agree) towards their game playing.

**4.3.2.3 Chinese children's views about educational games**

Only 17.3% (19 out of 109) children reported that they had heard of educational game before and only 10 out of 19 had played this kind of game before.

**4.3.2.4 Children's mobile phone use**

One hundred and four out of 109 (95%) Chinese children did not have their own mobile phones. Only five children (one girl and 4 boys) reported that they had their own mobile phones. Two of them owned their phones by age eleven and two owned by age ten, but one boy had a phone when he was eight. Only 2 children wrote down the brand of their mobile phone: Samsung and ZTE (Zhongxing Telecommunication Equipment).

Though most of the Chinese children did not have their own mobile phones, 106 out of 109 (97.2%) children had played mobile phone games before. Only three girls reported that they had not played mobile phone game before. Moreover, 23 out of 106 children (22.6%) had downloaded mobile phone game before and wrote down the name of the downloaded mobile phone games. Table 4.3.19 lists the names of girls' and boys' downloaded mobile phone games.

Table 4.3.19: The mobile phone games which were downloaded by girls and boys (Chinese Sample)

| Gender | games |
|---|---|
| girls and boys | PopKart, Transformers |
| girls | Battle between tanks, F1 racing car, Helicopter, Tower of Hanoi |
| boys | Counter striker, Zhengcheng, King of Fighters, Greedy snake, Menghuanxiyou, Ninja Turtles, Harry Potter, Cat and mouse, Jigsaw |

According to these 23 children (4 girls and 19 boys)'s response, boys reported that they had downloaded racing games (e.g. PopKart), shooting games (e.g. Counter striker), role-playing games (e.g. Zhengcheng, Menghuanxiyou), fighting games (e.g. King of Fighters, Ninja Turtles), puzzle games (e.g. Cat and mouse, Jigsaw, Greedy snake) and action game (e.g. Harry Potter, Transformers). Racing games and shooting games were popular with boys.

Girls reported that they had downloaded racing games (e.g. PopKart, F1 racing car), action games (e.g. Transformers, Helicopter) and puzzle games (e.g. Tower of Hanoi, Battle between tanks). Racing games and puzzle games were downloaded more by girls.

Mean scores for children's attitudes and boys' and girls' response separately to their attitudes towards playing mobile phone game were calculated and shown in table 4.3.20. An independent-samples t-test was conducted to compare the mean scores to see whether any gender difference was statistically significant.

Table 4.3.20 mean scores of overall and boys' and girls' response to their attitudes towards mobile phone games playing (Chinese Sample)

| Question | Overall Mean (SD) | Girls' Mean(SD) | Boys' Mean(SD) | t | Sig. |
|---|---|---|---|---|---|
| Do you like playing mobile phone games? | 3.60 (.943) | 3.50 (1.028) | 3.66 (.899) | .811 | .419 |

It can be seen from the Table 4.3.20 that the Chinese children tended to like playing mobile phone games, no matter whether boys or girls. T-test results indicated that there was no significant difference between boys and girls. ($p>.05$). Boys and girls did not differ in their views on this item.

### 4.3.3 DISCUSSION

This questionnaire investigated Chinese primary students' characteristics with regard to their use of electronic games, their electronic game preferences, and their thoughts on playing games alone, with parents or others. After comparing the results with Scottish students, there were some similarities and differences between Scottish students and Chinese students.

The results showed that the electronic game playing was a very popular activity for Chinese and Scottish students. One hundred percent of Scottish pupils had engaged in playing electronic games before and 85.8% (109 out of 127) pupils in China had played electronic games before. Though the game playing was very common and the study indicated that both Chinese and Scottish children tended to have positive attitudes towards electronic games playing, differences between Chinese and Scottish students' electronic game usage patterns were found in the study. The results revealed that the surveyed Scottish students played computer games frequently and spent much time on games. The majority of Scottish children played electronic games every day and spent over two hours per day on gaming. However, the surveyed Chinese children did not seem to play games as frequently or spend as much time on gaming. Less than 4% of Chinese pupils played electronic games every day and over 90% Chinese children played games mostly on weekends. Moreover, only 10% of Chinese children played electronic games more than one hour in a day. The difference in time spent on gaming might be because Chinese students had less free time than the Scottish students. According to a survey conducted by the Chinese Youth and Children Research Center, Chinese children spend 8.6 hours a day on average at school, with some spending 12 hours a day in the classroom (China Daily, 2007) and children also have a heavy load of homework to do and have little time to play (Naftali, 2010). Chinese students spend more time on extra study, more time taking extracurricular lessons; while they spend less time watching TV and videos, playing computer games, or playing and talking with friends (Wang, 2004). However, in Scotland children spend 6 hours a day at school. Moreover, MacBeath and Turner (1991) found that Scottish primary pupils stated that they took less than an hour in a typical evening on homework. As a result, Scottish children have more spare time to play.

Chinese boys in the present study reported spending significantly more time per day on playing electronic games than did Chinese girls. This result of gender differences in time spend on electronic game playing was consistent with previous research findings (e.g., Philips et al., 1995; Buchman & Funk, 1996; Funk, Buchman, & Germann, 2000; Fromme, 2003; Bonanno & Kommers, 2005) but was not the case with the Scottish sample.

Fun was found by many researchers (e.g. Prensky, 2001; McFarlane & Sakellariou, 2002; Kirriemuir & McFarlane, 2004) to be a great motivator for gaming, and most frequent computer and video game players said the number one reason they play games is because it is fun (Kirriemuir & McFarlane, 2004). Consistent with this pattern, in the present study, the fun element ranked the number one motivator for both Scottish and Chinese children. One interesting finding was that the motivation for playing appeared to be different between Scottish children and Chinese children. The fact that the game was exciting was the next most important motivator after analysing the choices of Scottish children, while the next most important motivator for Chinese children was they could learn from the game. According to Croll (2006), Chinese parents tend to insist that learning is more important than play, and parents favoured toys or games that are perceived to have educational aids. This information was in turn related to children's thoughts that games can help them learn. Moreover, Chinese parents often expected that their child worked hard in order to get good grades because a relatively common view in China is that a child's academic success leads to a promising future (Fong, 2004). Thus children spend a majority of their free time studying or enhancing their skills rather than playing or relaxing. These cultural factors reflect an interesting difference between Scottish and Chinese children in this study, that some Scottish children agreed that games may be a way of avoiding doing homework while almost no Chinese children mentioned playing electronic games when they did not want to do homework. One possible explanation of this difference is because learning is the most important thing for Chinese children and games ranked relatively low in priority after homework and other work related to study (Naftali, 2010). Moreover, children cannot get permission from parents to play games if they have failed to finish their schoolwork; as mentioned by a child, "My parents are not against playing computer games but against playing it when I have not finished my homework" (Anyaegbu, Ting & Li, 2011, p.161).

Even within the limited playing time, Chinese children also hope they are able to learn something during playing; this study indicated that over sixty percent of Chinese children stated that they favour playing puzzle games or a game which can help improve academic performance, when reporting their favourite game. The present study showed that Chinese children ranked puzzle games their number two favourite games while Scottish children ranked it number four and Scottish boys ranked this type of game last. Scottish children tended to regard games primarily as sources of enjoyment and for entertainment, while games seemed to be a learning medium for Chinese children rather than relaxing. As a result, educational games are important in China. Examples include

Mini MBA, Amazing Teacher, Game Class, K12 play, Wawayaya, Rescue Cinderella and Study in Dreamland. All these games were commercial games which were designed for stimulating Chinese students' study interest and supporting children's curriculum learning. Zhou (2006) found that normally parents did not like their children to play electronic games because they were worrying about the negative effect of some commercial electronic games. But parents' attitudes towards educational games were different and they supported children playing educational games which can help them learn (Zhou, 2006). Perhaps this is one of the reasons why Chinese parents did not seem to be strongly for or against games (as reported by the Chinese children); it depends on the type of game. This result was consistent with parents' views in Scotland, as reported by the Scottish children. However, an alternative explanation for both Scottish and Chinese children is maybe that they did not know their parents' attitudes, and so chose the central category.

In summary, the present study found some similar patterns of game use between the Scottish children and Chinese children and also some differences, which may be influenced by different policies and different cultural background.

# CHAPTER 5 STUDY TWO - PLAYING MOBILE PHONE GAME FOR CHILDREN'S MATHEMATICS LEARNING

The main aim of this study was to investigate whether classroom use of a mobile phone mental-agility game could influence children's learning and their mathematics attitudes. This study design is an experimental design, with pre-test and post-test, and an experimental group and a control group. The pre-post method used the same measure on two occasions and provided the opportunity to determine whether children's test score and mathematics attitudes changed during the intervention of the games. In this chapter, the researcher will present the procedures of the study and the data sources chosen to address the research questions. All the methods which were used to conduct the data collection and data analysis are also discussed within this chapter. This chapter also reports the findings from pre-test and post-test, questionnaire and interview, and discusses these results.

This study was designed to find answers to the following questions:

1. What is the impact of playing a mathematics mobile phone game on children's performance in mathematics over the period of the intervention?
2. What is the impact of playing a mathematics mobile phone game on children's attitudes towards mathematics over the period of the intervention?
3. What are children's opinions of the mathematics mobile phone game which was used in this study?

4. What is the perception of the teacher about using this mathematics mobile phone game in the classroom?

## 5.1 METHODOLOGY

The researcher will present the procedures for this study and all the methods which were used to conduct the data collection and data analysis are also described within the section.

### 5.1.1 PARTICIPANTS

The participants were a convenience sample. Because the research was targeted on primary school students and it was necessary to find a school which was easy to approach by public transport, the researcher sent requests to some possible primary school teachers in the Dundee and Angus area with the help of her supervisors. A P4 class teacher in an Angus primary school was happy to participate. This school was situated in a village near to Arbroath in Angus and followed the normal Scottish primary school curriculum. This primary school had a good reputation and recorded eight “excellent” indicators of quality such as teaching process, pupils’ learning experiences etc. and recorded six “very good” such as structure of the curriculum, pupils’ attainment in mathematics etc. in the report of HMIe 2008. The participants for this study consisted of a total of 17 Scottish students (14 boys and 3 girls) aged between 8 and 9. Moreover, the class teacher had used Nintendo DS for some mathematics work in the classroom previously. So the sample children had some experience of playing mathematics games on a game console as part of their mathematics work. However, that experience was limited.

## 5.1.2 RESEARCH INSTRUMENTS

### 5.1.2.1 Mobile phone game

A mobile phone java game entitled “Brain Challenge” was downloaded from a mobile game company GAMELOFT for this study. This game has four different tasks for training the brain: logical, memory, visual and mathematics. In the mathematics task there are three different games: Trout Route, Arithmetic and Tick Tock. The game Trout Route deals only with addition and subtraction. Once started, players can use the arrow keys on the keyboard to move up, down, left or right to choose the right answer (See Figure 5.1). The Arithmetic game deals with mixed addition, subtraction, multiplication and division. Players press the arrow keys to move left or right to choose the right answer (See Figure 5.2). The game Tick Tock is related to recognising time. Each game has three levels from easy to hard. Students had to play the first game Trout Route 5 times, then the second game Arithmetic would be unblocked. The third game would be unblocked after they had played the Arithmetic game 5 times. Because this study was designed to investigate children’s mental numeracy calculation, the game Trout Route and Arithmetic were used for intervention and the game Tick Tock was not used in this study.

Students would receive immediate feedback about whether they had answered correctly or incorrectly when they answered a question. Students had to solve the problems before the 90 seconds time was used up. The game displayed a performance summary immediately after each game finished. The summary showed the total number of correctly solved problems, the total number of incorrectly solved problems, the accuracy, the game score and the grade. Before playing each game the screen would display the highest score and grade of each level.

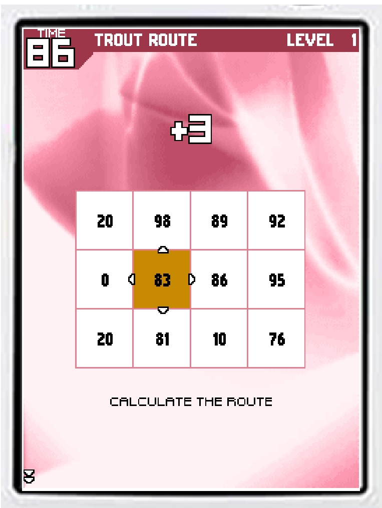


Figure 5.1: Example of mobile phone game: Trout Route

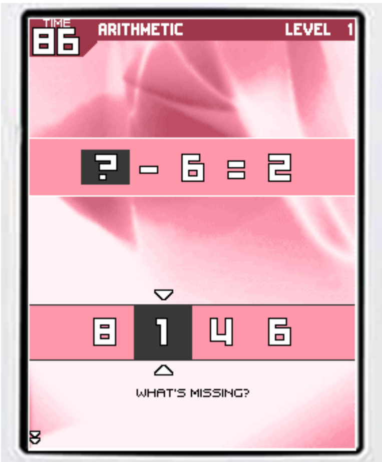


Figure 5.2: Example of mobile phone game: Arithmetic

In order to find a suitable mobile phone to download the game Brian Challenge, the researcher contacted the technical support of the mobile game company GAMELOFT and asked for a full list of mobile phones (brand and model) which can support the game. The technical supporter replied that the game Brain Challenge is supported by almost every phone in the market. So the researcher bought mobile phone LG GS101 for this study. This phone was one of the cheapest mobile phone in the market and cost around 20 pounds each.

#### 5.1.2.2 Mathematics test instrument

Three 60-item tests (the 'Mental Mathematics Challenge') were devised for measuring children's mental computation (See Appendix E). These tests included addition, subtraction, multiplication and division and were used for pre-test and two post-tests. In order to avoid children memorizing the order of the answers instead of the facts, each form of the three tests had the same problems, but in a different order. These mathematics questions were constructed to be stage appropriate, according to calculations required within Level C in the Scottish Mathematics curriculum (SOED, 1991). The researcher discussed with the class teacher as a further check on its suitability for children of this level before use. Answers were marked simply as correct or incorrect, with the range of scores therefore being from 0 to 60. Time taken to complete the challenge was also recorded. Children were to write the finished time on the mathematics challenge paper by themselves. A cut-off time was established at 15 minutes, after discussion with class teacher, and this time was assigned to any child who had not finished at the end of the testing period.

### 5.1.2.3 Mathematics attitude questionnaire

Fennema & Sherman (1976) proposed the Fennema-Sherman Mathematics Attitude Scales in 1976 and they are among the most popular instruments used in studies of attitudes towards mathematics over the last 30 years (Tapia & Marsh, 2004). The Fennema-Sherman Mathematics Attitude Scales consist of a group of 9 instruments:

- Attitude Towards Success in Mathematics Scale
- Mathematics as a Male Domain Scale
- Teacher Scale
- Mother Scale
- Father Scale
- Confidence in Learning Mathematics Scale
- Mathematics Anxiety Scale
- Effectance Motivation
- Mathematics usefulness Scale

The complete Fennema-Sherman Mathematics Attitude Scale (FSMAS) is composed of nine scales, each with twelve items. The original FSMAS would be too long and too time-consuming for primary students. It has been found that participants often lost interest as responding time went on (Mulhern & Rae, 1998). Moreover, the reliability and validity of the initial instrument may become less stable after more than 30 years (Chamberlin, 2010). Mulhern and Rae (1998) developed a shortened version with 51-item (six scales) 5-point Likert-type response format questionnaire based on an analysis of the original FSMAS. However, the representation of this shortened version was not the same as the original on each factor and they suggested that the scales might not gauge what they were intended to measure (Tapia & Marsh, 2004).

Tapia and Marsh (2004) proposed a new instrument (the Attitudes towards Mathematics Inventory) to measure students' attitudes towards mathematics. This instrument incorporated self-confidence, anxiety, and value, as well as enjoyment, motivation, and parent/teacher expectations. The 49-item instrument has a high level of reliability with a Cronbach alpha co-efficient of .96. When altered to a 40 item-instrument this reduced the original six variables to four, this reliability figure rose to .97. These 40 items investigated students' value, enjoyment, and motivation towards mathematics and they reported a high degree of internal consistency of the items in each one of the factors: the Cronbach alpha co-efficient scores on Self-confidence of .95, Value of .89, Enjoyment of .89, and on Motivation of .88. This means that the subscales have high level of reliability (Tapia & Marsh, 2004).

However, since the Attitudes towards Mathematics Inventory (ATMI) was developed using a sample of high-school students, the scale was not deemed suitable for repeated monitoring of students' attitudes in a primary class without any readjustment.

The researcher wanted to construct the items in the domain of attitudes toward mathematics to address factors reported to be important in research. The literature suggests that there is an important connection between these factors (self-confidence, value, enjoyment, and motivation) in mathematics and performance in mathematics. For example, Fennema and Sherman (1978) reported a positive correlation between perceived usefulness of mathematics and mathematical achievement. Lepper and Cordova (1992) stated that when learning is fun it appears to be more effective. More recently, Edwards (1998) suggests that children learn better when they are interested and motivated and Bouchey and Harter (2005) found that students' perceived confidence was a critical predictor of success in mathematics.

Also, the literature points to the influence of parents and teachers on students' attitudes towards mathematics. In previous research, it has been found that attitudes of parents and teachers about mathematics can motivate or discourage students to do mathematics (e.g. Kenschaft, 1991; Cai, Moyer, & Wang, 1997; Grootenboer & Hemmings, 2007). Grootenboer and Hemmings (2007) showed that a sample of students aged between 8 and 13 years rated as performing highly in mathematics by their respective teachers were more likely to have positive mathematics attitudes. This finding indicated that teacher's opinion of students' mathematics performance is an important factor in students' attitudes towards mathematics. In addition, Cai, Moyer, and Wang (1997) reported that students with good parents' support had higher mathematics achievement and more positive attitudes towards mathematics. So it is also important to measure students' perceptions of their teachers or parents' attitudes toward them as learners of mathematics.

So the researcher developed the mathematics attitudes scale based on ATMI items which were constructed to assess confidence, anxiety, value, enjoyment, motivation and added items to assess parent/teacher expectations.

It was also important to have an instrument which can be administered without taking too much class time. The students need to be able to complete the questionnaire quickly and accurately. The researcher minimised the number of ATMI items and changed some ATMI items in order to be suitable for primary students (e.g. The item “The challenge of math appeals to me” was changed to “I like the challenge of mathematics.”) Some other items were added because this is a game treatment study (e.g. I like playing mathematics games).

The instruments avoided the use of too many negatively worded items when constructing statements. The negative items often cause some hesitation or incorrect responses due to the logic of double negatives etc. Negatively worded items are commonly included in order to address possible acquiescence in response to items. Only eight items of this instrument were negative items.

The mathematics attitudes scales of this study consisted of 26 items with a straightforward factor structure. Items were constructed to assess five subscales: confidence, value, enjoyment, motivation and parent/teacher scale. The confidence scale was designed to measure students’ confidence and self-concept of their performance in mathematics. The value scale was designed to measure students’ beliefs on the usefulness and worth of mathematics. The enjoyment scale was designed to measure the degree to which students enjoy studying mathematics and playing mathematics games. The motivation scale was designed to measure interest in mathematics and desire to work in mathematics and play mathematics games. The parent/teacher scale was designed to measure the beliefs and expectations parents and teachers have of the students' ability and performance in mathematics.

A Likert-type scoring format was used for each of the subscales. Students were asked to indicate the extent of their agreement with each statement, on a five-point scale from strongly disagree to strongly agree (scored from 1 to 5). The mathematics attitudes scale questionnaire only contains closed questions. Gillham (2000, p.2) suggested developing a questionnaire by choosing this method: "the researcher has already decided on the possible answers: all he or she wants to find out is which answers are selected. This makes it very tidy for the researcher and easy to analyse."

The guidelines offered by Reid (2003, p.54) were used to guide development of the mathematics attitudes scale. For instance some of his statements are below:

> "Decide what types of questions would be helpful; Be creative and write down as many ideas for questions as you can; Select what seem the most appropriate from your list - keep more than you need; Keep the English simple and straightforward, avoid double negatives, keep negatives to a reasonable number, look for ambiguities, watch for double questions" (p.54)

Self-confidence was measured by 7 items. This scale includes items such as "Doing mathematics makes me feel nervous" and "I can get good marks in mathematics." The value scale consisted of 5 items. Sample items are "Mathematics is a very worthwhile and necessary subject" and "What I learn in mathematics is very important to me." Enjoyment was measured by 5 items. The scale includes items such as "I like playing mathematics games" and "I have usually enjoyed studying mathematics in school." The motivation scale consisted of five items. Sample items from this scale are "I look forward to doing mathematics" and "I like the challenge of mathematics." The parent/teacher scale was measured by 4 items. This scale included items such as "My parents are interested in my mathematics work" and "My teachers have made me feel I can do well in mathematics." (See Appendix F for more details)

When creating a scale, reliability is an important and fundamental characteristic of any measurement procedure. Cronbach's alpha is a valid method to estimate the reliability of measurement scales. The homogeneity of the total scale was found to be satisfactory when tested later, with the data collected. Cronbach's α of .930 (pre-test) and .946 (post-test) showed a high degree of internal consistency. These data indicate high level of reliability of the scores on the scale.

#### 5.1.2.4 Mobile phone game record sheet

A mobile phone game record sheet was developed to gain more information about children's playing (See Figure 5.3). The use of logs or diaries may provide a more dependable record, particularly for younger children (Cherney & London, 2006, p.723). Moreover, because the mobile phone game only recorded the best score of each level, the researcher wanted to know more details of playing – such as how many times children played every day, the playing scores and the playing grades each time etc. So the researcher designed a game record sheet for children to record the game level and score after each game was finished. The class teacher would note the reason if the children had not played the game on that day. These sheets could be used as a check on implementation fidelity. Implementation fidelity is “the degree to which teachers and other program providers implement programs as intended by the program developers” (Dusenbury, Brannigan, Falco, & Hansen, 2003, p.240).

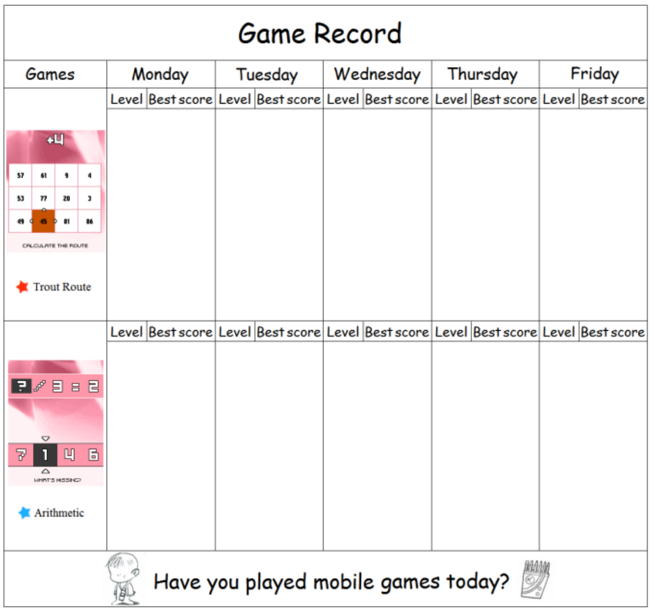


Figure 5.3: Mobile phone game record sheet

### 5.1.2.5 Game questionnaire

In order to get children’s opinions of the mobile phone game “brain challenge”, a Likert-type scoring format was used for two questions: “I like playing mobile game ‘brain challenge’.” and “Playing mobile game ‘brain challenge’ helps me make progress in math.” Students were asked to indicate the extent of their agreement with each statement, on a five-point scale from strongly disagree to strongly agree (scored from 1 to 5). (See appendix G for more details)

### 5.1.2.6 Interviews

Unlike questionnaires, interviews can get a wide range of possible responses from the respondents. Seven children (7 boys and 2 girls) were chosen to attend a group interview, randomly chosen by the class teacher. Group interviews, as opposed to individual interviews, can encourage children to open up and talk freely about what they did in the classroom. Furthermore, the synergistic effect of the group can help to produce ideas or data less forthcoming from a one-on-one interview (Stewart & Shamdasani, 1990). A semi-structured interview technique was used because a semi-structured interview is flexible, having some pre-set questions but allowing new questions to be brought up during the interview as a result of what the interviewee says.

The main purpose of the interview was to explore the perceptions of children about playing mobile phone games, help the researcher explain the quantitative results and explore the reasons that cause the game effects on the participants.

The following questions were designed to learn more about children's perceptions about playing mobile phone games.

- Have you played mobile phone games before?
- Did you like the mobile phone game 'brain challenge'?
- You have played two mobile phone games: Trout Route and Arithmetic. Which one do you like more? Why do you like this game?
- What are the good things about playing mobile phone games?
- What are the not-so-good things about playing mobile phone games?

- Compared with your normal mathematics work, which one is better?
- Do you think the mobile phone games have made you better in sums and why?
- When you played the mobile phone game, did you try to get a higher score or try to beat your friends' scores?
- Do you like playing other games at home?
- Do your parents like you playing games?

The setting for the interviews was a meeting room with a round table. The interview was conducted by the researcher and her supervisor in an informal and friendly atmosphere where the students were informed that all the information in the interview would be confidential. They were asked if the interview could be taped by voice recorder to help remember what they said. It was also explained that all the information would be held securely and only for this particular study. The interviews were conducted based on the pre-set questions. The questions asked in the interview may not have been exactly the same as the list above but all the questions were covered. If the participant seemed to misinterpret the question or did not understand the researcher's meaning, the researcher or the researcher's supervisor helped to explain the questions to clarify the question. The duration of interview was about 15 minutes. Following the interview sessions, the researcher transcribed the recordings.

In order to investigate the perception of the teacher about using mobile phone games in the classroom, the researcher did another interview with the class teacher at school. The interview was conducted by the researcher in the classroom with a friendly atmosphere where the teacher was also informed that all the information in the interview would be held securely and only for this particular study. A semi-structured interview technique using open-ended questions was used to follow leads and introduce new questions. Open-ended questions allow the respondent to include more information, and make possible deeper answers. This allows the researcher to better understand the respondent's comments and seek further explanation. The researcher used the voice-recorder to record the outcomes and the duration of interview was about 25 minutes. The interview record was transcribed after the interview finished.

The following questions were pre-set questions to know the teacher's opinions about using mobile phone games in general and the intervention game in the classroom.

- Tell me about your attitudes towards using mobile phone games in the classroom - before this project, and after.
- In your view, what are the benefits and disadvantages of mobile phone games?
- What do you think of the game 'brain challenge'?
- Do you feel children are more confident with mathematics as a result of this work?
- Will you use mobile phone games in the future?

### 5.1.3 PROCEDURE

The study was conducted over a six week period. Prior to pre-test, discussions had been held with the class teacher to explain the purpose of the study and clarify requirements. Parental permission forms were signed by children's parents and collected by the class teacher (See Appendix J for a copy of parental permission form). Students were informed that their participation in the study was completely voluntary and would not influence their grades. The pre-tests were administered in May 2009 – the mathematics test and mathematics attitudes questionnaire under the supervision of the class teacher and the researcher before the mobile phone gaming instruction was given. The researcher conducted a half-hour training session for the class teacher and students to help them become familiar with the mobile phone game "Brain challenge". Most students had previous experience playing mobile phone games and this game was easy to play. All students were able to play the games after the training session. The researcher also passed out the mobile phone game play sheet to children and told them how to fill it in. All mobile phone game play sheets were given to the class teacher after the training session. The class teacher collected in the play sheet when they played the mobile phone game every day.

There were seventeen children involved in this study. They were divided into two groups by random assignment. Random assignment was used to help ensure that the two groups were presumed to be equivalent in all ways except for the treatment. There were nine children in group 'A' and eight children in group 'B'. In the first three weeks, the group 'A' children played the mobile phone game first thing each day for 15 minutes, five days a week, playing the 'Brain challenge' game. The group 'B' children acted as no-treatment controls. After three weeks, all children played mobile phone game for 15 minutes in the morning every weekday at school for another three weeks. This meant that the two groups had differing amounts of time playing the games. The diagram below shows this.

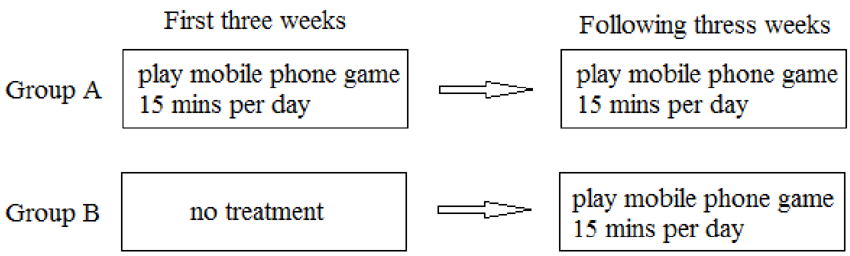


Figure 5.4: Two groups set up diagram

Two sets of post-test data were collected, the first one 3 weeks after the start, and the second one 6 weeks after the start. After conducting the second post-test, the researcher did two interviews, with a group of children and the class teacher separately on the same day. The diagram below shows the procedure of this study.

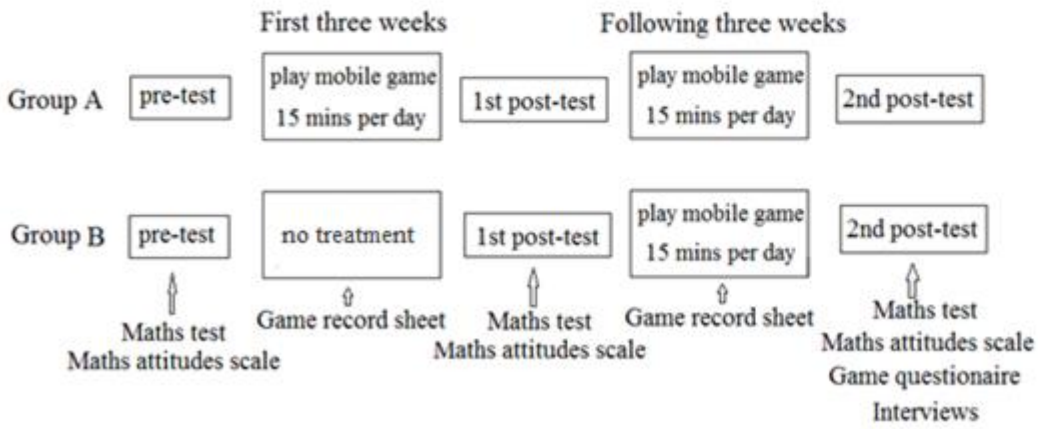


Figure 5.5: Procedure of mobile phone game study

5.1.4 DATA ANALYSIS

All the quantitative data were coded and analysed by using the SPSS Version 14.0 statistical package. A t-test was conducted to determine whether the means of the pre-test scores of the two groups differed significantly. Mean scores were calculated for the mathematics test at pre-test and post-test, and paired-samples t-tests applied to the data to look for any significant difference between them. The paired-samples t-test is used to compare data from two different occasions or under two different conditions and this technique is appropriate to pre-test/post-test experimental designs. So paired-samples t-tests were used in this study to see whether there were statistically significant differences in the mean scores of group 'A' children at Time 1 (pre-test) & Time 2 ($1^{st}$ post-test) and Time 1 (pre-test) & Time 3 ($2^{nd}$ post-test) and group 'B' children at Time 1 (pre-test) & Time 2 ($1^{st}$ post-test).

Some reverse scoring was necessary on the questionnaire before the analysis of the data. Each positive item received the score based on points from 1 to 5. The scoring for each negative item was reversed from 5 to 1. For example, if children strongly agree with the item 'I look forward to doing mathematics.', the score will be given a numerical value of 5. But if children strongly agree with this negative item 'I would like to stop doing mathematics in school.', the score will be given 1. Mean scores for the overall attitudes scale, and for each subscale, were calculated at pre-test and two post-test, and paired-samples t-tests also applied to the data.

The study involved 17 students (14 males and 3 females). The participants were overwhelmingly male, therefore no attempt was made to compare results by gender.

The qualitative data from the students' interview were analysed by summarising the students' response to the interview questions. Similarly the data from the teacher's interview were analysed by summarising her response to the interview questions.

The findings and the results of these analyses are presented in the results section at 5.2 below.

## 5.2 FINDINGS

This section will present the information that was gathered from mobile phone game record sheet, three sets of tests and questionnaires which included the mathematics performance test, the mathematics attitudes scale and mobile phone game questionnaire, and interview findings from the participant class teacher and seven students.

### 5.2.1 CHANGES IN CHILDREN'S MATHEMATICS PERFORMANCE OVER THE PERIOD OF THE INTERVENTION

In order to investigate whether there is possibility that the two groups differed in terms of their ability in mental calculation at the start of this study, a t-test was conducted on the pretest score for two groups. The results indicated that the two groups did not differ significantly on these measures at pretest: scores on number attempted [$t(15) = -1.326$, $p = 0.205$], scores on answers correct [$t(15) = -1.182$, $p = 0.255$], time taken [$t(15) = -2.115$, $p = 0.06$].

#### 5.2.1.1 Children's mathematics performance in mobile phone game group and no treatment control group

In the first three weeks, group 'A' children played mobile phone game and group 'B' children acted as a no treatment control group. Mean scores were calculated for number attempted, answers correct, and time taken at pre-test and after 3 weeks treatment, and paired-samples t-tests applied to the data. A percentage accuracy level was established by taking the number of correct responses and dividing them by the number of attempted responses. The percentage accuracy rate was calculated both at pre-test and 3 weeks post-test and paired-samples t-tests also applied to the data. The findings are summarized in Table 5.2.1, Table 5.2.2, Table 5.2.3 and Table 5.2.4.

Table 5.2.1: Mean scores on number attempted (first 3 weeks)

| Group | Condition | n | Mean score<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| ‘A’ | Mobile phone game | 9 | 39.78 (17.28)<br>46.33 (14.81) | +6.55 | .103 |
| ‘B’ | No treatment | 8 | 49.00 (9.87)<br>53.25 (7.59) | +4.25 | .355 |

Table 5.2.2: Mean scores on answers correct (first 3 weeks)

| Group | Condition | n | Mean score<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| ‘A’ | Mobile phone game | 9 | 34.78 (17.26)<br>41.89 (14.06) | +7.11 | .078 |
| ‘B’ | No treatment | 8 | 43.00 (9.91)<br>46.25 (6.48) | +3.25 | .380 |

It can be seen that the mobile phone game group (‘A’) and no treatment group (‘B’) both appeared to show improvement in the number of attempted and correct answers in the test but the differences for these two groups did not achieve significance. This means we have to conclude that there was no significant improvement in the scores of either group over the time period.

Table 5.2.3: Percentage accuracy rate on mathematics test (first 3 weeks)

| Group | Condition | n | Mean rate<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Mobile phone game | 9 | 85 (7.70)<br>89 (7.67) | +4 | .209 |
| 'B' | No treatment | 8 | 88 (1:10)<br>87 (2:59) | -1 | .948 |

It can be seen that the mobile group 'A' showed an increase in the percentage accuracy rate from 85% to 89% but the difference was not statistically significant. The slight reduction in the percentage accuracy rate for no treatment group 'B' was also non-significant. These results indicated that there was no significant change in the percentage accuracy rate for either group.

Table 5.2.4: Mean time on mathematics test (first 3 weeks)

| Group | Condition | n | Mean time<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Mobile phone game | 9 | 11:32 (3:33)<br>10:45 (4:20) | -0:47 | .234 |
| 'B' | No treatment | 8 | 14:16 (1:10)<br>12:50 (2:59) | -1:26 | .254 |

There was reduction in the time taken by the pupils to complete the mathematics test in the mobile group 'A' and the no treatment group 'B'. But the change over time in each group was non-significant. There was no significant change in the time taken by either group.

In all, the comparison of the result of the first post-test and the pre-test on the mathematics challenge test indicated that the scores of the experimental group children for number attempted, accuracy, speed of computation, and percentage accuracy rate were better at time 2; however, the differences did not achieve significance. Similarly, changes in scores for the control group were also non-significant. The conclusion reached is that neither group improved their performance significantly over the three week period.

#### 5.2.1.2 The difference of children's mathematics performance between 3 weeks treatments and 6 weeks treatments

After the first three weeks, group 'A' children continued to play the mobile phone game for another three weeks. This second phase of the experiment allowed us to compare children playing games for a three weeks' period and a six weeks' period. The results of mean scores on number attempted, mean scores on answers correct, the percentage accuracy level and mean times were calculated for the pupils to complete the mathematics test and the paired-samples t-tests results are summarized in Table 5.2.5, Table 5.2.6, Table 5.2.7, and Table 5.2.8.

Table 5.2.5: Mean scores on number attempted (6 weeks)

| Period of time on mobile phone game | Group | n | Mean score<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 39.78 (17.28)<br>46.33 (14.81) | +6.55 | .103 |
| 6 weeks | 'A' | 9 | 39.78 (17.28)<br>45.33 (15.98) | +5.55 | .177 |

Table 5.2.6: Mean scores on answers correct (6 weeks)

| Period of time on mobile phone game | Group | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 34.78 (17.26)<br>41.89 (14.06) | +7.11 | .078 |
| 6 weeks | 'A' | 9 | 34.78 (17.26)<br>41.44 (16.29) | +6.36 | .104 |

It can be seen that the scores for group 'A' in number attempted and correct answers in the three weeks post-test rose. The number attempted and correct answers of group 'A' in total were still higher at the six weeks post-test. However, the gains were a slight decrease compared with the three week post-test. The gains in scores did not achieve significance, either in three weeks treatment or six weeks treatment. This means that there were no significant differences in either group in number attempted and correct answers after playing mobile phone for three weeks or six weeks.

Table 5.2.7: Percentage accuracy rate on mathematics test (6 weeks)

| Period of time on mobile phone game | Group | n | Mean rate pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 85 (7.70)<br>89 (7.67) | +4 | .209 |
| 6 weeks | 'A' | 9 | 85 (7.70)<br>90 (7.16) | +5 | .023 |

The mean scores for percentage accuracy increased from 85% to 89% in the first three weeks and from 89% to 90% in the following three weeks. Though the gains in the three week period did not achieve significance, there were significant improvements when measured over a six week period. This means that pupils' percentage accuracy improved significantly over a 6 week period.

Table 5.2.8: Mean time on mathematics test (6 weeks)

| Period of time on mobile phone game | Group | n | Mean time<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 11:32 (3:33)<br>10:45 (4:20) | -0:47 | .234 |
| 6 weeks | 'A' | 9 | 11:32 (3:33)<br>8:58 (4:26) | -2.34 | .010 |

It can be seen that the scores for group 'A' pupils in the time taken to complete the mathematics test during the first three weeks treatment fell, and the mean scores fell further in the second period of treatment. Though the reduction in the first three week period did not achieve significance, there was a significant reduction in the time taken by the pupils in group 'A' after 6 weeks treatment.

In summary, although there were no significant changes over a three-week period, children made a significant improvement in the speed of computation and percentage accuracy rate with a longer 6-week period treatment. In contrast, there were no significant changes in the number attempted and accuracy even after the six week period. Taken together these findings suggest that a 6 week period may be beneficial for the learners in speed and accuracy rate.

### 5.2.1.3 Summary of mathematics test

The experience of working with the mobile phone game in the first three weeks has not contributed to a significant improvement in the number attempted, accuracy, speed of computation and percentage accuracy rate.

After six weeks, the picture changed. Although there was still no significant gain in number attempted and accuracy, there were significant improvements in the speed of computation and percentage accuracy rate after six weeks treatment.

On the whole, the findings provide evidence to show a positive effect of playing the mobile mathematics games over a longer, six-week period, on the participants' achievement in some, but not all areas.

### 5.2.2 CHANGES IN CHILDREN'S MATHEMATICS ATTITUDES OVER THE PERIOD OF THE INTERVENTION

In addition to the performance measures, the researcher was interested in whether children's attitudes had been influenced as a result of intervention. As with the performance data, a t-test was conducted on the pre-test scores for the two groups. In this case the results indicated no significant difference between the groups on the measures at pre-test: [$t(15) = 0.271$, $p = 0.79$]. These findings indicated that the two groups did not differ significantly at the start of the project in terms of their mathematics attitude.

#### **5.2.2.1 Children's mathematics attitudes in the mobile phone game group and no treatment group**

Group 'A' children played the mobile phone game and group 'B' children had their regular lessons for three weeks. All pupils completed the mathematics attitude scale before and after treatment. Mean scores were calculated for mathematics attitudes at pre-test and post-test, and repeated measure t-tests applied to the data. The findings of overall mathematics attitudes are summarized in Table 5.2.9.

Table 5.2.9: Mean scores on mathematics attitude (first 3 weeks)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Mobile phone game | 9 | 113.44 (14.37)<br>114.22 (14.29) | +0.78 | .792 |
| 'B' | No treatment | 8 | 111.25 (18.93)<br>110.50 (21.29) | -0.75 | .805 |

It can be seen that there was a slight increase in the mean score for mathematics attitude for group A over time, and a fall for group B over time. Tests showed that the change in score for each group was non-significant. This means that there was no significant change in attitude for either group over the three-week period.

As described earlier, the mathematics attitudes scales consisted of five subscales and subscales scores were computed for those: confidence, value, enjoyment, motivation and parent/teacher scale. The results are summarized in Table 5.2.10.

Table 5.2.10: Mean scores on sub-scales of mathematics attitude (first 3 weeks)

| Subscale | Group | Condition | n | Mean score pre/post (SD) | Change | Sig |
|---|---|---|---|---|---|---|
| confidence | ‘A’ | Mobile phone game | 9 | 27.89 (4.99)<br>29.33 (4.39) | +1.44 | .412 |
| | ‘B’ | No treatment | 8 | 27.13 (6.08)<br>28.25 (6.07) | +1.12 | .875 |
| motivation | ‘A’ | Mobile phone game | 9 | 22.67 (3.57)<br>22.22 (3.67) | -0.45 | .548 |
| | ‘B’ | No treatment | 8 | 22.13 (4.55)<br>21.50 (4.90) | -0.63 | .577 |
| value | ‘A’ | Mobile phone game | 9 | 22.22 (2.59)<br>23.00 (2.35) | +0.78 | .325 |
| | ‘B’ | No treatment | 8 | 22.25 (3.54)<br>21.38 (3.85) | -0.87 | .462 |
| enjoyment | ‘A’ | Mobile phone game | 9 | 21.89 (4.14)<br>21.67 (4.18) | -0.22 | .695 |
| | ‘B’ | No treatment | 8 | 21.75 (4.62)<br>21.75 (4.80) | +0 | 1 |
| parent & teacher | ‘A’ | Mobile phone game | 9 | 18.78 (1.48)<br>18.00 (2.40) | -0.78 | .088 |
| | ‘B’ | No treatment | 8 | 18.00 (2.07)<br>17.63 (2.87) | -0.37 | .685 |

It can be seen from Table 5.2.10 that there was a slight increase in mean scores for the mobile phone game group ‘A’ of the attitude scale in mathematics confidence, and mathematics value, and a slight fall in mean scores for mathematics motivation, enjoyment and parents and teachers. But all the differences were non-significant, This finding indicated that children did not differ in these five subscales of mathematics attitudes after playing mobile phone for three weeks. In contrast, there was only a slight increase in the mean score for the no treatment group of the attitude scale in mathematics confidence. The changes in all five subscales of mathematics attitudes for non-treatment group were also non-significant. It can be concluded that there were no significant changes in all five subscales of mathematics attitudes of either group over the three-week period.

#### 5.2.2.2 The difference in children's mathematics attitudes between 3 weeks treatments and 6 weeks treatments

After the first three weeks game playing, Group 'A' children played mobile phone game for another three weeks. The following are the findings comparing three weeks of game playing with six weeks playing. Mean scores were calculated for mathematics attitudes at pre-test, 1$^{st}$ post-test and 2$^{nd}$ post-test, and repeated measure t-tests applied to the data. The findings of overall mathematics attitudes and means scores of subscales are summarized in Table 5.2.11, Table 5.2.12.

<u>Table 5.2.11: Mean scores on mathematics attitude (6 weeks)</u>

| Period of time on mobile phone game | Group | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 113.44 (14.37)<br>114.22 (14.29) | +0.78 | .792 |
| 6 weeks | 'A' | 9 | 113.44 (14.37)<br>111.67 (18.35) | -1.77 | .732 |

It can be seen from Table 5.2.11 that there was a slight increase of the mean scores of overall mathematics attitudes after three weeks game playing and slight fall after six weeks game playing; however, neither achieved significance. This means that there was no significant change in attitude after playing mobile phone for three weeks or six weeks.

Table 5.2.12: Mean scores on sub-scales of mathematics attitude (6 weeks)

| Subscale | Group | Period of time on mobile phone game | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|---|
| confidence | 'A' | 3 weeks | 9 | 27.89 (4.99)<br>29.33 (4.39) | +1.44 | .412 |
| | 'A' | 6 weeks | 9 | 27.89 (4.99)<br>29.22 (6.14) | +1.33 | .547 |
| motivation | 'A' | 3 weeks | 9 | 22.67 (3.57)<br>22.22 (3.67) | -0.45 | .548 |
| | 'A' | 6 weeks | 9 | 22.67 (3.57)<br>21.78 (4.15) | -0.89 | .303 |
| value | 'A' | 3 weeks | 9 | 22.22 (2.59)<br>23.00 (2.35) | +0.78 | .325 |
| | 'A' | 6 weeks | 9 | 22.22 (2.59)<br>22.11 (3.52) | -0.11 | .930 |
| enjoyment | 'A' | 3 weeks | 9 | 21.89 (4.14)<br>21.67 (4.18) | -0.22 | .695 |
| | 'A' | 6 weeks | 9 | 21.89 (4.14)<br>20.44 (4.45) | -1.45 | .208 |
| parent & teacher | 'A' | 3 weeks | 9 | 18.78 (1.48)<br>18.00 (2.40) | -0.78 | .088 |
| | 'A' | 6 weeks | 9 | 18.78 (1.48)<br>18.11 (3.22) | -0.67 | .518 |

It can be seen from Table 5.2.12 that the changes in each subscale were very slight and none achieved significance. This meant that children did not differ in mathematics attitudes after playing mobile phone whether over a three weeks or a longer six weeks period.

### 5.2.2.3 Summary of mathematics attitudes scale

The experience of working with the mobile phone game in the first three weeks appeared to have no significant difference in overall mathematics attitudes and all five subscales. The difference in overall mathematics attitudes and all five subscales of the no treatment group students also showed no significant difference.

The overall scores for mathematics attitudes in six weeks showed a slight fall and all the mean scores of subscales were slightly down compared with the results in three weeks treatment periods. Again, all the differences were non-significant.

On the whole, the findings indicated that there seems no positive effect of playing the mobile phone games on children's mathematics attitudes, whether over a three weeks or a longer six weeks period.

### 5.2.3 QUESTIONNAIRE ABOUT CHILDREN'S ATTITUDE TOWARDS PLAYING MOBILE PHONE GAME 'BRAIN CHALLENGE'

Group 'A' children completed this questionnaire after three weeks game playing and again after six weeks game playing. Group 'B' children completed this questionnaire only after their three weeks game playing. To investigate students' opinions of this mobile phone game "brain challenge" in the two groups, descriptive analyses of each statement were conducted (See Table 5.2.13, Table 5.2.14, Table 5.2.15 and Table 5.2.16). The researcher changed the Likert scale points from 1 to 5 when analysing the data.

Table 5.2.13: Children's attitude towards statement "I like playing mobile game 'brain challenge'."(6 weeks)

| Group | Period of time on mobile phone game | n | Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|---|
| 'A' | 3 weeks | 9 | 7/9 | 2/9 | / | / | / |
| 'A' | 6 weeks | 9 | 8/9 | 1/9 | / | / | / |
| 'B' | 3 weeks | 8 | 6/8 | 1/8 | 1/8 | / | / |

All group 'A' children and seven of eight group 'B' children strongly agree or agree with the statement "I like playing mobile game 'brain challenge'." when they answer the questionnaire. Only one girl in group 'B' neither agreed nor disagreed with this statement.

Table 5.2.14: Descriptive statistics for children's attitudes towards statement "I like playing mobile game 'brain challenge'."(6 weeks)

| Period of time on mobile phone game | Group | n | Mean score | SD |
|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 4.78 | .44 |
| 6 weeks | 'A' | 9 | 4.89 | .33 |
| 3 weeks | 'B' | 8 | 4.63 | .74 |

It can be seen from the Table 5.2.14 that children like playing the mobile phone game "brain challenge" and the mean score increased after 6 weeks game playing compared with three weeks.

Table 5.2.15: Children's attitude towards statement "playing mobile game 'brain challenge' helps me make progress in math."(6 weeks)

| Group | Period of time on mobile phone game | n | Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|---|
| 'A' | 3 weeks | 9 | 8/9 | 1/9 | / | / | / |
| 'A' | 6 weeks | 9 | 8/9 | / | / | 1/9 | / |
| 'B' | 3 weeks | 8 | / | 5/8 | 3/8 | / | / |

The majority of children strongly agree or agree with the statement "Playing mobile game 'brain challenge' helps me make progress in math." after three weeks game playing or six weeks game playing.

Table 5.2.16: Descriptive statistics for children's attitude towards statement "playing mobile game 'brain challenge' helps me make progress in math."(6 weeks)

| Period of time on mobile phone game | Group | n | Mean score | SD |
|---|---|---|---|---|
| 3 weeks | 'A' | 9 | 4.89 | .33 |
| 6 weeks | 'A' | 9 | 4.67 | 1 |
| 3 weeks | 'B' | 8 | 3.63 | .52 |

It can be seen from the Table 5.2.16 that group 'A' children agreed with the statement "playing mobile game 'brain challenge' helps me make progress in math." after 3 weeks game playing and 6 weeks game playing, but there is a slight fall after 6 weeks compared with three weeks. Group 'B' children were less positive, being closer to the middle of the scale.

In all, the majority of children like playing the mobile phone game ‘brain challenge’ and they thought playing the mobile phone game help them improve in math.

### 5.2.4 GAME RECORD SHEET

The children were asked to put the game level and score after each game finished. The class teacher would put the reason if the children had not played the game on that day.

The findings of playing times from the game record sheets are summarized in Table 5.2.17 and Table 5.2.18.

Table 5.2.17: The number of times children played the games with group ‘A’ and ‘B’children

| Group | First three weeks | Following three weeks | Total playing time |
|---|---|---|---|
| ‘A’ | 378 | 557 | 935 |
| ‘B’ | / | 634 | 634 |

Table 5.2.18: The playing times on each mobile phone games ‘Trout Route’ and ‘Arithmetic’

| Group | ‘Trout Route’ | ‘Arithmetic’ | Total |
|---|---|---|---|
| ‘A’ | 641 | 294 | 935 |
| ‘B’ | 413 | 221 | 634 |

It can be seen from Table 5.2.17 that pupils’ playing times increased from the first three week period to the second. The findings indicated that children did not lose interest during six weeks of game playing. The data in Table 5.2.18 showed that children spent more time on playing 'Trout Route' than 'Arithmetic'.

When children played the mobile phone game, they were able to select a game difficulty level from among three choices: "easy," "medium" and "hard". The game displayed a performance score from 'Star', 'A', to 'F' immediately after each individual game ended. The score result 'Star' means the best performance and the 'F' means the lowest. The number of individual playing times which get higher performance score 'Star', 'A' or 'B' when they choose the easy level are summarized in Table 5.2.19.

Table 5.2.19: The number of playing times which get higher performance score Star' or 'A' or 'B' when children choose level 'easy'

| Group | Occasions when higher performance scores were achieved ('Star', 'A' or 'B') | Total playing times | % of Total |
|---|---|---|---|
| 'A' | 148 | 751 | 19.7% |
| 'B' | 94 | 451 | 20.8% |
| Total | 242 | 1202 | 20.1% |

It can be seen from Table 5.2.19 that children attempted to play the game 1202 times but there were only 20.1% playing times when children got high scores. This result indicated that it may be rather difficult for the children to achieve a good game result. This suggests the mathematics content may be bit difficult for the ability of the sample children. This finding will revisit later in this chapter (Section 5.3).

## 5.2.5 INTERVIEW

In addition to the quantitative data collected through the tests and surveys, two interviews were conducted, one with the class teacher and the other with seven students randomly selected by the class teacher (five boys and two girls). The interview purpose was to explain quantitative results on the effects of the games on mathematics achievement and motivation of the participants and to identify the causes of such effects on the participants.

### 5.2.5.1 The students' views

All interviewed students reported that they liked playing the mobile phone games 'brain challenge' and did not feel bored because they enjoyed the game approach. Five of the seven interviewed children liked playing the mobile phone game 'Trout Route' more than the game 'Arithmetic' because the game 'Trout Route' only has two kinds of question - addition and take away. 'Trout Route' 'gives you more things to do' because 'The Arrows on Trout Route you can move up, sideways and down'. Another reason for favouring ''Trout Route'' was that the game involved adding big numbers. Though it was a bit difficult, the children seemed to enjoy the challenge of it. In contrast, a child mentioned that s/he preferred playing 'Arithmetic' because 'You just need to think of the answer in your heads and then just go on' instead of moving your fingers up and down lots of times.

In addition, the children mentioned it was easier when they were playing the mobile phone game 'because you don't need to write anything down'. A child said the game makes you 'think quick'. Another child stated that 'you get to do more levels and harder ones'. These comments suggest that children were enjoying the challenge aspect of the games. Overall, the children liked everything about the games and they did not report any bad aspects of playing mobile phone games. Most of the children stated that they were mainly trying to beat their own score. Only one child mentioned s/he was mainly trying to beat friends' score. During the game they only cared about the game score, no trying to finish quicker. This is interesting because it suggests that the children are competing with themselves – not just trying to beat their friends.

All interviewed students believed that playing the mobile phone game had made them better in sums and stated why they thought that. For example, children mentioned that there seemed there weren't many hard sums 'because there are hard sums in some of them' or 'next time you might be seen one (hard sum)'. A child thought s/he can solve the hard sums because 'there are hard sums you have be thinking about and even more'. Moreover, children stated they improved the speed of processing as one child said 'Make you work quite faster as well'.

Compared with their normal mathematics work (Teejay Mathematics), three of the seven interviewed children preferred playing mobile phone games because 'playing games is fun' and they liked the challenge to 'get a higher score'. On the other hand, four out of seven children liked doing their normal mathematics work, because 'it's easier when you do Teejay because you can count on your fingers' and 'you are not against the clock'. Perhaps these answers suggest that children find the Teejay Mathematics is less of a challenge.

Most of the children (5 out of 7) had played a mobile phone game before and some children even stated that they had their own mobile. Children mentioned the following things they normally did at home: playing Xbox, playing Nintendo, playing with phone, watching TV, reading book, playing with friends, and staying inside (to) do homework. Four children said playing games was their very favourite thing at home. Some of the children stated that their parents like them playing electronic games at home but some of the children said their parents did not.

#### 5.2.5.2 The teacher's views

The class teacher reported that she was keen to carry out this project because she had already used the Nintendo DS in the classroom and wanted to see how the mobile phone games compared with the activities using the Nintendo. After running this project, she reported that she liked the mobile phones and the games and she believed that the mobile phone game motivated the students. On the other hand, she didn't like it quite as well as the Nintendo because mobile phone games 'takes longer to set them up' and there could be disruptions, unlike the Nintendo. For example, 'sometimes text messages come through and sometimes the phone rings'. She also mentioned the organisational point of view, suggesting that managing the games as a group activity was not always easy. Managing two groups for 15 minutes each was a 'big chunk' of her time because of having half an hour used up. She reported that if all the pupils had their own phone and the game could be done altogether it would be easier for her and slot better into the routine.

The teacher also reported that the children's previous Nintendo game experience had helped the children manage the mobile phone game more easily and quickly. Moreover, using handheld games showed great improvement with children's self-management and children were able to continue those skills with mobile phones. In terms of motivation, the teacher reported that the mobile phone games make children more interested in and confident in learning mathematics. She mentioned a significant benefit, that the game helped a boy improve his self-confidence. This boy couldn't do a good job with written work but with the games he could keep up, because he was slow at written work, rather than slow at learning. She said that 'his brain can go quickly but he can't get information from his brain to his hands to increase the speed of written work'. Because there is no written part of the game, the boy did very well in gaming and 'he's always excited by the game score'. However the teacher stated that fewer children share their mobile phone game results and the performance score of the game was not clear like Nintendo games. This means that children didn't know their self-improvement because they can't get the ranking results of each game, unlike Nintendo games.

The teacher emphasized the motivation aspect, and reported that the game situation can catch children's attention quickly and make children more interested than a text book can. The management of the resources would have to be changed though. She would continue to use mobile phone games in the future, but 'if we have the mobile phones in the classroom all the time, I will again set up a different organisation and different timetable: get mobile phones on certain days, maybe Nintendo on other days, so it's ideal for the children. We will work like that'.

## 5.3 DISCUSSION

The main aim of this study was to investigate whether classroom use of a mobile commercial game could influence children's learning and mathematics attitudes. The study found that the children in the mobile phone game group did not show significant improvement in the number attempted, accuracy, speed of computation and percentage accuracy rate after three weeks training. The findings seem to suggest a similar trend to some prior research such as those reported by Ke (2008b) and Boticki et al. (2010), indicating that using the games had no significant difference in mathematics achievement. The findings seem to suggest a different trend to some prior empirical research which indicated that there was a significant effect of computer gaming on students' mathematics learning, such as those reported by Miller and Robertson (2010), Ke and Grabowski (2007), Moreno (2002), Rosas et al. (2003), and Laffey et al. (2003). However this result may be tempered by the fact that only a small number of children were involved. This is in comparison with several previous studies, for example, in Miller and Robertson (2010)'s study, they examined 71 children, and there were 634 students involved in another study by them in 2011. Rosas, et al. (2003) investigated a larger sample with 1,274 children. However, in the current study only 17 children were involved, 15 children participated in Ke (2008b)'s study and 16 students in Boticki et al. (2010)'s study.

Compared with the results after three weeks game playing, the children in the mobile phone game group improved significantly in speed and percentage accuracy rate after six weeks game playing. This indicates that more game playing seemed to have a more positive impact on children's learning. This result was consistent with the study of Shin et al. (2006) who found the performance of children who play handheld game for 13 weeks (15 minutes, three or four times per a week) outperformed the children who played a game for 13 weeks but only 2 times per week. The fact that improvements were seen over a longer, six week period may point to a minimum length of time for benefits to be seen. Compared with previous mental mathematics studies, the period of treatment in this study was relatively short. For example, Miller and Robertson (2010) found significant improvement after 10 weeks game playing and they found positive impact in another study with 9 weeks game playing (Miller & Robertson, 2011). Main and O'Rourke (2011) also did a 10 weeks intervention study.

In fact, in this study, the mobile phone game group children missed an average of five sessions in the first three weeks and this may have affected the children's performance, preventing them from gaining the full benefit. This may be one of the reasons why the figures failed to reach significance in the first three weeks. Thus trying to guarantee children's attendance was also important. Moreover, the findings of this study that children did not feel bored and had positive attitudes towards mobile phone game playing after six weeks game playing indicated that the game can motivate them to play for six weeks. It may be that a longer time game playing could have more significant effects on mental mathematics performance beyond those found in this study. However, there needs to be more studies and more evidence to justify the length of study.

Students in this study did not seem to have significantly more positive attitudes toward mathematics after 3 weeks or 6 weeks of mobile phone gaming. The findings of previous studies about the effect between the mathematics attitudes and the use of electronic games were also mixed, with positive impact (e.g. Ke, 2008; Costu et al., 2009) or partial impact (e.g. Ke & Grabowski, 2007; Pareto et. al, 2011) or no impact (e.g. Cankaya & Karamete, 2009; Miller & Robertson, 2010, 2011). Though the mixed results maybe a result of using different measurement scales, two studies by Ke and Grabowski (2007) and Ke (2008) used the same scale of a modification of Tapia's ''Attitudes Towards Math Inventory" (ATMI) (Tapia & Marsh, 2004) to assess children's attitudes towards mathematics. Ke and Grabowski (2007) found no positive impact on competitive game playing while Ke (2008) found positive impact on game playing. As a result, there still needs to be more investigation into the effect of computer gaming on students' attitudes toward mathematics.

However, table 5.2.19 showed that this mobile phone game may be a bit difficult for children to achieve good game results. The TEEM (Teachers Evaluating Educational Multimedia) data suggested that the degree of difficulty is an important facet if children are to enjoy playing. The game must be neither too difficult nor too hard (McFarlane et al., 2002). This mobile phone game may not have made the mathematics problem 'appropriately difficult'. In addition, the teacher stated that it was difficult for children to know their self-improvement after playing the game each time. Also, because of the difficulty of game, most children got the grade such as 'C' or 'D' even 'E' after each playing and it was difficult for them realize the change in their performance within the scoring system of this mobile phone game.

This uncertainty may help to explain why children's mathematics attitudes have not shown significant improvement after three weeks mobile gaming and even a slight drop after six week playing because a key motivation component (appropriate difficulty level) may have been absent in this mobile phone game playing. As discussed by Malone (1981), an engaging game should have an obvious and compelling goal. So it is important to balance the challenge level of a game with students' competency level when using a game in the classroom for primary school students.

The current study contributes further insights to the existing literature of the electronic game effectiveness as it differs from the previous studies with regards to the type of game used as treatment, the research method and design. This study tested the effects of mobile phone games, while previous empirical studies used more sophisticated hand-held game consoles like Nintendo DS (e.g. Miller & Robertson, 2010; 2011; Main & O'Rourke, 2011), handheld games like Nintendo's Gameboy (e.g. Rosas et al, 2003, Shin et al., 2006;) or computer games (e.g. Laffey et al., 2003; Tuzun, et al., 2009; Pareto et al., 2011). Those games are more sophisticated, but many costs are involved in game play: in addition to owning a hand-held game console such as Nintendo DS, gamers must invest approximately £120 for a gaming system and £20 for each game that they want to play. The costs are also higher for using a computer game or Nintendo game boy. On the other hand, the cost of a mobile phone is very much lower, with approximately £20 for a cheap mobile phone and £2 for the game. So the mobile phone is more attractive for schools with limited budgets.

However, the sample class teacher mentioned some problems with mobile phones such as they can ‘take longer time to set up’, ‘sometimes text messages come through’ and ‘sometimes the phone would ring’. Because this project was conducted in 2009, with the development of technology in recent years, this is less of a problem now. Phones with more powerful processors allow the games to be run in a few seconds. And if the game has been downloaded to the phone, the mobile phone game can be run without the Sim card. This will mean that there will no interruptions by the phone ringing or text messages coming in.

In summary, this study provided some evidence that a commercial mobile phone game which was used in a primary classroom can have a positive impact on primary students’ mental mathematics learning. The study also supports claims made in previous literature that electronic games can be an effective learning tool for help students’ learning (e.g. Malone, 1981; Prensky 2001a, 2005, 2010; Gee, 2003a, 2005, 2007). Moreover, the present study used children’s game record and interview data to explain the results of quantitative tests. The findings of this study indicated that a combination of quantitative tests and qualitative data provided valuable insights into the effects of the mobile phone game and the practical issues for teachers which could not have been discovered through quantitative tests alone, such as the study from Miller and Robertson (2010) or Ke and Grabowski (2007). However, the findings cannot be generalised from the current study to other classes or schools, because the sample size is small. Also, there are other characteristics which mean that the school may not be typical: the school is a small school with good reputation, is located in the east of Scotland and the duration of game experiences is extremely modest. In spite of this, the nature of the study may be replicable in other Scottish school conditions because the children have the same mathematics curriculum and teachers were trained under the same Scottish scheme.

# CHAPTER 6 STUDY THREE - PLAYING ONLINE FLASH MATHEMATICS GAME FOR CHILDREN'S MATHEMATICS LEARNING

This study helped the researcher to investigate whether online flash mathematics games can influence children's mathematics learning and affect their attitude towards mathematics. This study is also a pre-post design and involves an experimental group and a control group. However, in this case, the control group is not a no-treatment group. In this study, the control group was learning the same subject matter, but not through technology. This study was designed to find out the following questions:

1. What is the impact of playing online flash mathematics games on children's performance in mathematics over the period of the intervention?
2. What is the impact of playing online flash mathematics games on children's attitude towards mathematics over the period of the intervention?
3. What is the difference in impact on children's mathematics performance and mathematics attitude between online game and paper-pencil mathematics game which used similar cognitive processes?
4. What are the children's attitudes towards these online games?
5. What is the perception of the teacher about using mathematics online flash games in the classroom?

## 6.1 METHODOLOGY

The researcher will present the procedures for this study and all the methods which were used to conduct the data collection and data analysis are also discussed within the section.

### 6.1.1 PARTICIPANTS

The participants were again a convenience sample. Because the teacher involved in the previous mobile phone game study had expressed an interest in being involved further in this study, she was asked again. As she had changed class, this questionnaire involved the same teacher but not the same pupils. Fifteen primary three students participated in this study. They were 6-8 years old, 6 being girls. Their mathematics abilities were classified into three ability levels, based on their teacher’s assignment. This information supplied by the class teacher informed the choice of mathematics problems provided for each ability level, both for the web-based game and for the non-computer activity which the control group did. These are described in section 6.1.2 below.

## 6.1.2 RESEARCH MATERIALS AND INSTRUMENTS

### 6.1.2.1 Online game platform

To prepare the participants to take part in the study and gather the required data from the participants, a password protected web games platform had already been designed by the researcher as the main instrument for this research. In study two, the class teacher had mentioned that she could not track children's game performance because there was no log-in system on the mobile phone. In this study, in order to solve this problem, each child was given a unique username and password to log into the game platform, so the teacher could trace every child's game performance. However, unfortunately because of a configuration conflict of Web browser Internet Explorer (IE) with the school computers, the history of the children's game score could not be displayed on the screen of the computers at school. This meant that the class teacher still could not check the children's game playing score at school. Similarly, children could not know their game score history and the best score in each game either.

Because children's mathematics abilities varied within the class, the class teacher had divided the children into three groups. The platform had three group calculation games with mathematical content. Each group had five mathematics games, using a mouse to click the answer (See example in Figure 6.1) or using the keyboard to input the answer (See example in Figure 6.2) within their set menu. The games were designed with different mathematics problems according to the children's mathematics ability. All games were developed by the researcher using Macromedia Flash to run in the major

Web browser Internet Explorer. Children could choose any game from five games in the menu to play. The lowest ability group had games which only involved addition, and all numbers were up to 100. The middle group had these and also had subtraction. The numbers were also up to 100. The top group only had division and the numbers were only dividing 2, 3, 5 and 10. Each game had instructions which told participants how to play the game. The play time was 20 minutes. All children's playing history was stored in the database.


Figure 6.1: Example of mathematics game requiring clicking to choose the answer


Figure 6.2: Example of mathematics game requiring answer to be typed

### 6.1.2.2 Paper-based Mathematics card game on worksheets

A parallel paper card game was also prepared, as the alternative to the online games. A mathematics activity box was prepared. In each box there were 100 mathematics calculation questions, written on cards. The questions were also designed according to children’s mathematics ability and the questions were similar to the online games questions. The least able group had 100 questions which only involved addition and all numbers were up to 100. The middle group had 100 questions which involved addition and subtraction. The numbers were also up to 100. The top group only had divisions and the numbers were only dividing 2, 3, 5 and 10. Children chose one question from the box and wrote the question and the answer on their worksheets. Children tried to answer as many questions as they could in 20 minutes. The purpose of this paper-based card game was to be as close as possible in learning to the online game. This meant the control group had the same length of time practising the same mathematical processes as the experimental group. (See appendix M for an example copy of children’s worksheet).

#### 6.1.2.3 Mental Mathematics Test

Three 60-item tests (the “Mental Mathematics Challenge”) were devised for measuring children’s mental computation according to their mathematics ability (See appendix K for more details). Because children’s mathematics abilities varied, the researcher constructed three differentiated tests; these were based on information received from the teacher about the children’s previous performance. The lowest ability group had 60 questions which only involved addition and all numbers were up to 100. The middle group had 60 questions which included addition and subtraction. The numbers were also up to 100. The top group only had divisions and the numbers were only dividing 2, 3, 5 and 10. Different level pupils therefore used different tests. The researcher discussed with the class teacher the content and structure as a further check on its suitability for children of this level before use. Each group of students did the same test in pre-test and two post-tests. Answers were marked simply as correct or incorrect, with the range of scores therefore being from 0 to 60. Time taken to complete the challenge was also recorded. Children wrote the finished time on the mathematics challenge paper by themselves. A cut-off time was established at 20 minutes after discussion with class teacher, and this time was assigned to any child who had not finished at the end of the testing period.

#### 6.1.2.4 Mathematics attitude scale

The researcher administered the same mathematics attitude scale questionnaire which was used in study two to measure participants' attitude (See appendix F).

#### 6.1.2.5 Game Questionnaire

A nine questions questionnaire (See appendix L) was devised for this study and contained a range of different types of questions including closed questions and open-ended questions. By using closed questions it gave the opportunity to analyse the frequency of the children's answers (Cohen, Manion & Morrison, 2007) for their views on using the online computer games and their views on whether the games improved their mathematics skills. The use of open-ended questions gave an insight into the children's thinking such as why they liked the games or why they thought the games helped them improve their mathematics.

In more detail, this questionnaire involved three different question formats:

(1) multiple-choice method

a. Single tick questions: one question tried to investigate children's attitude towards online game by using a 5-point Likert scale. Students could choose their opinions from five categories: very much, a bit, not sure, not very much, not at all.

b. Multiple tick questions: one item asked children to select one or more online games which they liked most from a list. This question had a follow-up open question about why they liked the game.

(2) Yes or No questions, some with follow-up questions according to their answer. There were three questions. For example: Children could choose Yes or No when they answered whether they thought they had improved their mathematics though playing games or whether they liked to continue learning mathematics through playing games. These questions were followed by a question to state why they said that.

(3) Free text question: this kind of question was used to find out children's feeling towards the online game.

#### 6.1.2.6 Interviews

In order to investigate the perception of the teacher about using online mathematics games as part of her normal teaching, the researcher did an interview with the teacher at school. The interview was conducted in the classroom with a friendly atmosphere where the teacher was informed that all the information in this interview would be held securely and only for this particular study. The researcher used a voice-recorder to record the interview and a semi-structured interview technique and open-ended questions were used to follow leads and introduce new questions. Open-ended questions allow respondents to include more information, provide deeper answers and this allows researchers to better understand what the respondent truly believes about an issue in the interview situation. The duration of interview was about 45 minutes. The notes were transcribed after the interview finished (see Appendix O).

The following questions were pre-set questions to investigate the teacher's opinions about using online games in the classroom.

- How well are the children achieving?
- What is the children's engagement in gaming and the paper-pencil card game?
- When children play the online game, do they ask for help?
- Do children try to get a higher score or try to beat friends' scores?
- Any difficulty in using the online game in the classroom?
- Will you use the game instead of a textbook?

### 6.1.2.7 Observations

In order to investigate how children played the online games, the researcher also conducted observations at the school. Knight (2002) states that observations can provide process data - they are a good source to use as they often establish what happens. Knight indicated that this is important because most studies examine what people's beliefs are about what they do – but what they do generally tends to be different from what they say and think. The observations took about 20 minutes in a section of the school where four children played the online games unsupervised by the teacher. See appendix N for the observation sheet.

### 6.1.3 PROCEDURE

Prior to the treatment period, discussions had been held with the class teacher to explain the purpose of the study and clarify requirements. A demonstration was done for the class teacher in order that she could then help the children to become familiar with how to use the game platform and play online games. Platform username and password were set up by the researcher and sent to the class teacher by email before the project began.

Fifteen children were divided into two groups by stratified random assignment. Students were first divided on the basis of attainment by the teacher: high, average or low as described earlier. Within each level they were then randomly assigned to either group 'A' or 'B'. This strategy is useful and makes the two groups roughly similar when the members of a population are dissimilar and, therefore, helped the researcher identify the effect of the games on the participants with different levels of achievement. There were eight children (two in lowest ability group, one in top and five in middle) in group ‘A’ and seven children (two in lowest ability group and five in middle) in group ‘B’.

A within-subjects design was used. A within-subjects design is a type of experimental design in which all participants are exposed to every treatment or condition. In this study, all the children did both tasks, online game and card game, in a counter-balanced manner. I counterbalanced the order of the conditions to make sure that the practice effects were distributed equally across both conditions of the experiment. In January 2010 the group ‘A’ children began the intervention programmes, playing online mathematics games for 20 minutes each day at school, and the group ‘B’ children did the prepared paper-pencil based mathematics card game, supervised by their regular teacher for four weeks. After the 4-week post-test, the two groups were changed. A slight change to the plan was needed at this point. Because of other school activities and holidays, Group ‘A’ children had only played the online games seventeen times, rather than the expected 20. In order to provide consistency, it was necessary to use the game program an equal amount of times across two groups, so the second period had to be changed to seventeen times. Group ‘B’ children began to play games for 20 minutes each day at school and Group ‘A’ children did the paper-pencil based mathematics game for seventeen times. The diagram below shows this.

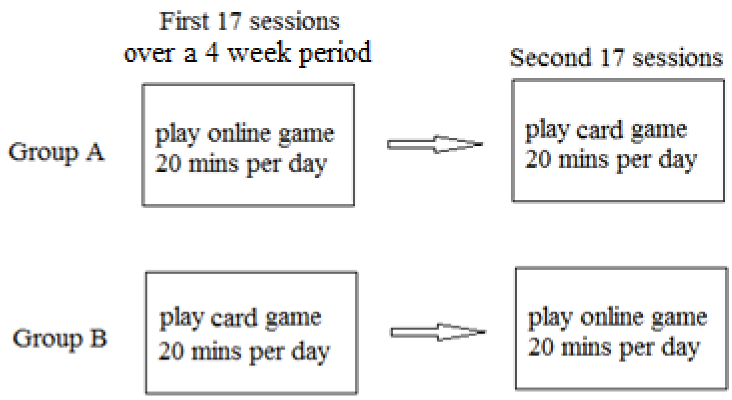


Figure 6.3: Two groups set up diagram

All children took the respective mathematics test and finished the mathematics attitude scale under the supervision of the class teacher and the researcher before the gaming intervention began. Two sets of post-test data of mathematics test and mathematics attitude scale were collected, the first one 17 sessions after the start, and the second one after all 34 sessions. In the second post-test, children also finished a questionnaire about their views on the online mathematics games which they were involved with. The researcher conducted an individual interview with the class teacher two weeks later.

During the implementation stage of Group 'B', children playing the online games, the researcher conducted an observation at school where four children played the online games without any supervision. The main purpose of the observation was to gather more qualitative information about children playing online games.

The diagram below shows the procedure of this study.

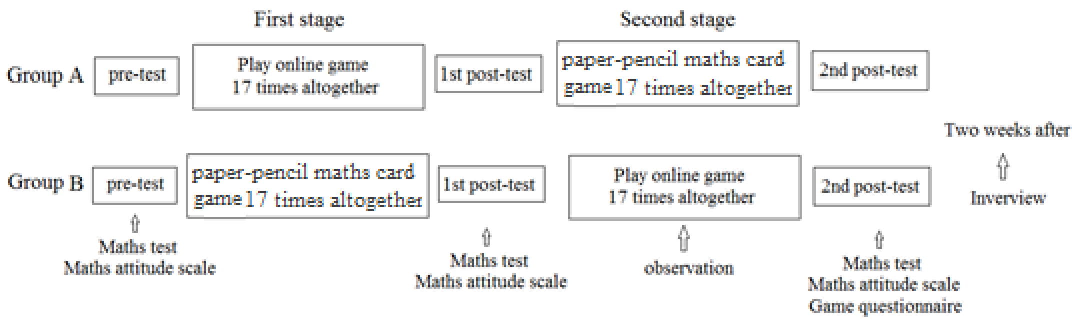


Figure 6.4: Procedure of online game study

### 6.1.4 DATA ANALYSIS

All the quantative data were coded and analysed using the SPSS Version 14.0 statistical package. The researcher changed the Likert scale points when analysing the attitude data, in a similar way to the data analysis in the study of the mobile phone game study (see Chapter Five section 5.1.4 for more details). The study involved 15 students (11 males and 4 females). The participants were overwhelmingly male; therefore no attempt was made to differentiate results by gender. The findings and the results of these analyses are presented in the results section at 6.2 below.

The qualitative data from the teacher's interview were analysed by summarising her response to the interview questions (see Appendix O and section 6.1.2.6). The data from the observation in the school were analysed with a view to identify factors which influenced the student's learning.

## 6.2 FINDINGS

This section will present the information that was collected from three sets of tests and questionnaires which included the mathematics performance test, the mathematics attitude scale and the online game questionnaire, together with observation findings and interview findings from the class teacher.

### 6.2.1 CHANGES IN CHILDREN'S MATHEMATICS PERFORMANCE OVER THE PERIOD OF THE INTERVENTION

In order to investigate whether there is a possibility that the two groups differed in terms of their ability in mental calculation at the start of this study, a t-test was conducted on the pretest score for two groups. The results indicated that the two groups did not differ significantly on these measures at pretest: scores on number attempted [$t(13) = 0.194$, $p = 0.849$], scores on answers correct [$t(13) = 0.681$, $p = 0.508$], time taken [$t(13) = 0.169$, $p = 0.868$].

#### 6.2.1.1 Children's mathematics performance on online game and paper-pencil based mathematics card game in the first 17 sessions

In the first 17 sessions, group 'A' children played the online game and group 'B' children did the paper-pencil based mathematics card game. Mean scores were calculated for number attempted, answers correct and mean times to complete the mathematics test, at pre-test and after 17 sessions treatment. Repeated measure t-tests were applied to the data. The findings are summarized in Table 6.1, Table 6.2 and Table 6.3.

Table 6.1: Mean scores on number attempted (first 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Online games | 8 | 41.88 (8.32)<br>46.50 (12.63) | +4.62 | .237 |
| 'B' | Paper-pencil card game | 7 | 40.86 (11.95)<br>47.57 (14.49) | +6.71 | .094 |

Table 6.2: Mean scores on answers correct (first 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Online games | 8 | 38.38 (7.84)<br>41.25 (12.42) | +2.87 | .443 |
| 'B' | Paper-pencil card game | 7 | 34.43 (14.14)<br>41.57 (13.06) | +7.14 | .022 |

Table 6.3: Mean time on mathematics test (first 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Online games | 8 | 19:54 (0:15)<br>18:24 (3:01) | -1:30 | .211 |
| 'B' | Paper-pencil card game | 7 | 19:53 (0:19)<br>17:52 (3:23) | -2:01 | .144 |

It can be seen from Table 6.1, Table 6.2 and Table 6.3 that the online games playing group (Group 'A') and the paper card game group (Group 'B') both showed gains in mean scores for number attempted and answers correct and a reduction in the time taken in the mathematics test.

There was a statistically significant improvement of group ‘B’ in answers correct from pre-test (M=34.43, SD=14.14) to post-test (M=41.57, SD=13.06), $p<.05$. All other differences were non-significant. This means that the paper and pencil card game contributed to improvements in children’s performance. This was the only area where there was a significant change in either group.

#### 6.2.1.2 Children’s mathematics performance on online game and paper-pencil based mathematics card game in the following 17 sessions

In the following 17 sessions, group ‘A’ children did the paper-pencil based mathematics card game and group ‘B’ children played the online game. Mean scores were calculated for number attempted, answers correct at 1st post-test and 2nd post-test, mean times were calculated for the pupils to complete the mathematics test, both at 1st post-test and 2nd post-test and repeated measure t-tests applied to the data. The findings are summarized in Table 6.4, Table 6.5 and Table 6.6.

Table 6.4: Mean scores on number attempted (following 17 sessions)

| Group | Condition | n | Mean score<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| ‘A’ | Paper-pencil card game | 8 | 46.50 (12.63)<br>54.50 (5.76) | +8 | .069 |
| ‘B’ | Online games | 7 | 47.57 (14.49)<br>48.86 (12.60) | +1.29 | .790 |

It can be seen that the mean scores for number attempted rose over time for each group. However, repeated-measures t-tests indicated that these gains were non-significant. Therefore we conclude there was no significant improvement in numbers attempted over this time in either group.

Table 6.5: Mean scores on answers correct (following 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Paper-pencil card game | 8 | 41.25 (12.42) 49.13 (6.33) | +7.88 | .059 |
| 'B' | Online games | 7 | 41.57 (13.06) 42.14 (10.48) | +0.57 | .905 |

It can be seen that an increase in the mean score for answers correct for both group over time. Tests showed that the change in score for each group was non-significant. This means that there was no significant change in numbers correct for either group over this period.

Table 6.6: Mean time on mathematics test (following 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Paper-pencil card game | 8 | 18:24 (3:01) 16:03 (3:45) | -2:21 | .052 |
| 'B' | Online games | 7 | 17:52 (3:23) 17:36 (4:10) | -0:16 | .886 |

It can be seen from Table 6.6 that the online games playing group and the card game group both showed improvement in the speed of calculation but the differences were statistically non-significant after repeated-measures t-tests. This means there was no significant change in the time taken by either group.

#### 6.2.1.3 Children's mathematics performance on online game and paper-pencil based mathematics card game over the full period of the experiment

The two sets of analyses above were based on the group (i.e. half-class) comparisons. However, this experiment was set up as a within-subjects design (see earlier comments in the methodology) where the children in both groups did both tasks, but in a different order (see Figure 6.5). This means that we can combine the scores from both groups when looking at the effects of each task. This has the benefit of increasing the sensitivity of the comparisons since the numbers are larger.

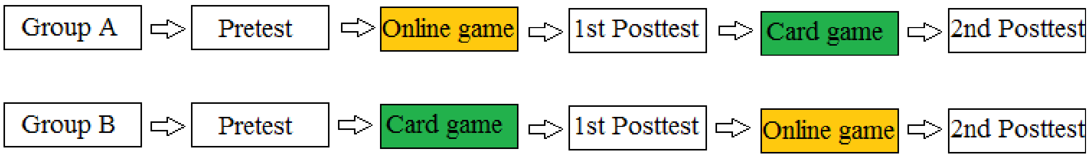


Figure 6.5: The procedure of two groups

In order to see a clearer picture of children's mathematics performance, mean scores were calculated for number attempted, answers correct and mean times for all the pupils in each condition. Repeated measure t-tests were applied to the data. The findings are summarized in Table 6.7, Table 6.8 and Table 6.9. 'Pre' and 'Post' score in Table 6.7, Table 6.8 and Table 6.9 are the mean scores before and after their experiences with that treatment. For example, in table 6.7, for the online games condition, the mean score for the 15 children was 44.53 before they played the game, and 47.60 afterwards.

Table 6.7: Mean scores on number attempted

| Condition | n | Mean score<br>pre / post (SD) | Change | Sig |
|---|---|---|---|---|
| Online games | 15 | 44.53 (11.54)<br>47.60 (12.22) | +3.07 | .293 |
| Paper-pencil card game | 15 | 43.87 (12.22)<br>51.27 (10.93) | +7.4 | .009 |

<u>Table 6.8: Mean scores on answers correct</u>

| Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|
| Online games | 15 | 39.87 (10.32)<br>41.67 (11.15) | +1.8 | .525 |
| Paper-pencil card game | 15 | 38.07 (13.24)<br>45.60 (10.41) | +7.53 | .003 |

<u>Table 6.9: Mean time on mathematics test</u>

| Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|
| Online games | 15 | 18:57 (2:27)<br>18:02 (3:29) | -0:55 | .367 |
| Paper-pencil card game | 15 | 19:06 (2:17)<br>16:54 (3:35) | -2:12 | .011 |

It can be seen from Table 6.7, Table 6.8 and Table 6.9 that there was a mean gain in number attempted, answers correct and speed of calculation in the mathematics test when the children played the online games, but a greater gain, more than with online games, when they played the card game. In order to see whether these gains could have arisen by chance, repeated-measures T-tests were applied to the data. These indicated that the change for the online group was non-significant whereas the change for the card game group was significant. This means that the improvement in the card game group was unlikely to have arisen by chance, but the gains with the online group were not large enough to allow us to say that.

However, a key question in this study was, is there a difference between the two conditions: the computer game and the control condition (the card-based game)? Although the gains for the card-game are larger than the online game, we cannot say with confidence that one condition was better than the other, because these were within-groups tests, to measure change over time. We cannot be sure that the difference *between the two conditions* was significant. In order to investigate that, between-groups t-tests were conducted to compare gain scores on number attempted, on answers correct and time taken in online game and paper-pencil card game conditions. The results are shown in the following section.

#### 6.2.1.4 The difference in children's mathematics performance between conditions: online game and paper-pencil based mathematics card game

After analysis with the whole class of children, there was not a significant difference between the mean scores on number attempted for online game (Gain=3.07) and card game (Gain=7.4); $t(14)=-1.190$, $p = 0.254$. The difference between the scores on answers correct using online game (Gain=1.8) and using paper-pencil card game (Gain=7.53) was not significant ($t(14)=-1.333$, $p=0.204$). There was no significant difference between the scores on time taken using online game (Change=-0:55) and using paper-pencil card game (Change=-2:12); $t(14)= 1.109$, $p=0.286$).

These results indicate that even with this more sensitive analysis, although the scores suggest that the card game group actually did better, the differences were not large enough to achieve significance. Therefore we have to accept that the differences may have arisen by chance. We cannot say that one method produced better results.

#### 6.2.1.5 Summary

The findings of the card game condition were statistically significant – gains in number attempted, accuracy and speed of computation (see Table 6.7, 6.8 and 6.9). The changes in number attempted, answers correct and time taken in the online game condition were not significant. However, although these findings suggested that the paper-pencil group might have been more effective, a between-groups comparison showed that the difference was non-significant. Therefore, we cannot say with certainty that the two conditions differed. These findings are both surprising and important, and will be discussed later in this chapter.

### 6.2.2 CHANGES IN CHILDREN'S MATHEMATICS ATTITUDE OVER THE PERIOD OF THE INTERVENTION

In addition to the performance measures, the researcher was interested in whether children's attitude had been influenced as a result of the intervention. As described above in section 6.1.2.4, the mathematics attitude scale used in this study is the same mathematics attitude scale which was used in study two. The mathematics attitude scales consisted of five subscales related to confidence, value, enjoyment, motivation and parent/teacher scale.

#### 6.2.2.1 The difference in children's mathematics attitude for the online game group and paper-pencil based mathematics card game group in the first 17 sessions

In the first 17 sessions, group 'A' children played the online game and group 'B' children did the paper-pencil based mathematics card game. As with the performance data, mean scores of overall mathematics attitude and mean scores for each subscale were calculated at pre-test and after 17 sessions' treatment and repeated measures t-tests applied to the data. The findings are summarized in Table 6.10 and Table 6.11.

Table 6.10: Mean scores on overall mathematics attitude (first 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Online games | 8 | 78.93 (14.37)<br>78.95 (21.41) | +0.02 | .992 |
| 'B' | Paper-pencil card game | 7 | 93.57 (13.01)<br>87.72 (17.55) | -5.85 | .068 |

It can be seen from table 6.10 that children's overall mathematics attitude has a slight increase from pre-test (M=78.93, SD=14.37) to post-test (M=78.95, SD=21.41) after playing the online game but a notable decrease from (M=93.57, SD=13.01) to post-test (M=87.72, SD=17.55) after playing the paper-pencil mathematics card game. Neither achieved significance ($p > .05$). This means that there was no significant change in attitude for either group over the first 17 sessions.

Table 6.11: Mean scores on sub-scales of mathematics attitude (first 17 sessions)

| Subscale | Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|---|
| confidence | ‘A’ | Online games | 8 | 24.51(3.39)<br>25.90 (3.77) | +1.39 | .117 |
| | ‘B’ | Paper-pencil card game | 7 | 25.42 (5.00)<br>22.15 (6.06) | -3.27 | .170 |
| motivation | ‘A’ | Online games | 8 | 12.25 (3.47)<br>13.14 (3.62) | +0.89 | .151 |
| | ‘B’ | Paper-pencil card game | 7 | 16.58 (2.06)<br>16.00 (3.60) | -0.58 | .729 |
| value | ‘A’ | Online games | 8 | 13.65 (2.09)<br>13.64 (2.84) | -0.01 | .994 |
| | ‘B’ | Paper-pencil card game | 7 | 18.14 (2.17)<br>18.14 (1.19) | +0 | 1 |
| enjoyment | ‘A’ | Online games | 8 | 12.14 (3.71)<br>11.51 (3.96) | -0.63 | .504 |
| | ‘B’ | Paper-pencil card game | 7 | 17.43 (1.72)<br>15.28 (2.83) | -2.15 | .130 |
| parent & teacher | ‘A’ | Online games | 8 | 16.38 (1.88)<br>14.76 (1.66) | -1.62 | .125 |
| | ‘B’ | Paper-pencil card game | 7 | 16.00 (0.95)<br>16.15 (1.19) | +0.15 | .856 |

The results from table 6.11 indicate that the online game group showed a slight improvement on subscales of confidence and motivation, and their scores dropped on value, enjoyment and parent/teacher subscales, The mean scores of paper-pencil mathematics card game group had a slightly improvement on parent/teacher subscale and a drop on subscales of confidence, motivation and enjoyment of mathematics. The mean score for mathematics value had no change. When the t-test was conducted, none of these changes achieved significance for these two groups. These results suggest that that there was no significant change on the mathematics attitudes subscales of the participants who played the online game or did the paper-pencil mathematics card game during the first 17 sessions.

#### 6.2.2.2 The difference in children's mathematics attitude for the online game group and paper-pencil based mathematics card game group in the following 17 sessions

In the following 17 sessions, group 'A' children did the paper-pencil based mathematics card game and group 'B' children played the online game. The findings of mean scores of overall mathematics attitude and mean scores for each subscale of mathematics attitude are summarized in Table 6.12 and Table 6.13.

Table 6.12: Mean scores on overall mathematics attitude (following 17 sessions)

| Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|
| 'A' | Paper-pencil card game | 8 | 78.95 (21.41)<br>81.83 (19.73) | +2.88 | .279 |
| 'B' | Online games | 7 | 87.72 (17.55)<br>98.86 (9.36) | +11.14 | .001 |

It can be seen from Table 6.12 that children's overall mathematics attitude has an increase from pre-test (M=87.72, SD=17.55) to post-test (M=98.86, SD=9.36) after playing the online game. T-test results showed the improvement was significant. This means that there was a significant improvement in mathematics attitudes after playing the online game.

There was a slight improvement from pre-test (M=78.95, SD=21.41) to post-test (M=81.83, SD=19.73) after playing the paper-pencil mathematics card game but the difference was non-significant (p>.05). This means that there was no significant change on mathematics attitudes after playing the paper-pencil mathematics card game.

Table 6.13: Mean scores on sub-scales of mathematics attitude (following 17 sessions)

| Subscale | Group | Condition | n | Mean score pre / post (SD) | Change | Sig |
|---|---|---|---|---|---|---|
| confidence | ‘A’ | Paper-pencil card game | 8 | 25.90 (3.77)<br>25.89 (1.94) | -0.01 | .995 |
| | ‘B’ | Online games | 7 | 22.15 (6.06)<br>27.28 (2.07) | +5.13 | .078 |
| motivation | ‘A’ | Paper-pencil card game | 8 | 13.14 (3.62)<br>12.90 (3.47) | -0.24 | .780 |
| | ‘B’ | Online games | 7 | 16.00 (3.60)<br>18.28 (2.29) | +2.28 | .031 |
| value | ‘A’ | Paper-pencil card game | 8 | 13.64 (2.84)<br>15.14 (2.05) | +1.50 | .099 |
| | ‘B’ | Online games | 7 | 18.14 (1.19)<br>19.43 (1.19) | +1.29 | .155 |
| enjoyment | ‘A’ | Paper-pencil card game | 8 | 11.51 (3.96)<br>12.14 (3.09) | +0.63 | .694 |
| | ‘B’ | Online games | 7 | 15.28 (2.83)<br>17.29 (0.91) | +2.01 | .175 |
| parent & teacher | ‘A’ | Paper-pencil card game | 8 | 14.76 (1.66)<br>15.76 (2.19) | +1.00 | .546 |
| | ‘B’ | Online games | 7 | 16.15 (1.19)<br>16.58 (1.16) | +0.43 | .391 |

The results from Table 6.13 indicate that the online game group gained an increase in all five subscales, but only the motivation scale achieved significance after t-test from pre-test (M=16.00, SD=3.60) to post-test (M=18.28, SD=2.29). These results suggest that the mathematics online games had a positive effect on children’s motivation but there was no significant difference on other four subscales.

The mean scores of the paper-pencil mathematics card game group showed a slight improvement on mathematics value, mathematics enjoyment and parent/teacher subscales, and a slight drop on the attitude subscales of confidence and motivation of mathematics. Tests showed that the changes for five subscales were non-significant. The findings suggested that there was no significant change in all five subscales of mathematics attitude for the paper-pencil mathematics card game group.

#### 6.2.2.3 Summary

The online game intervention improved children's motivation in mathematics significantly. Apart from this, there was no significant change on the other four subscales of mathematics attitudes for children after playing the online game (confidence scale, value scale, enjoyment scale and parent/teacher scale). In addition, there was no significant change in all five subscales of mathematics attitude after playing paper-pencil card game.

### 6.2.3 QUESTIONNAIRE ON CHILDREN'S OPINIONS ABOUT THE ONLINE MATHEMATICS GAME USED IN THE STUDY

Group 'A' and Group 'B' children all did a game questionnaire, which was designed to understand their opinions of the online mathematics game, at the end of this project. As described in section 6.1.2.5, this questionnaire contained nine questions including closed questions and open-ended questions. I will describe the findings of children's opinions on the online game in the following section.

#### 6.2.3.1 Do they like playing the online mathematics games?

The Table 6.14 below summarises the categories the children were in with their responses to the question, do they like playing the online mathematics games.

Table 6.14: children's attitude towards playing online game

| | Very much | A bit | Not sure | Not very much | Not at all |
|---|---|---|---|---|---|
| Number of Children | 5 | 4 | 1 | 3 | 2 |
| % of Total | 33.3% | 26.7% | 6.7% | 20% | 13.3% |

It can be seen from the Table 6.14 that nine of 15 children (60%) children seemed to have positive attitude towards online gaming because they said that they liked, or liked a bit, playing online games. Five children said that they did not like playing online games.

#### 6.2.3.2 Feelings towards the online mathematics games

In order to give an insight into the children's thinking, an open-ended question was used. This question asked the children to write down their feelings towards the online mathematics games. Nine of 15 children reported that they liked the online games or they thought the games were good or they wanted to play more games. Three children reported that the game was easy or boring and two children said the games were tricky or kind of hard. One child reported that he never wanted to play the computer game.

#### 6.2.3.3 The reason for choosing their favourite online mathematics games used in this study

Nine of 15 children reported that they liked the games because the games were easy. Two children stated that the games were adding games. Two children said they liked the games because the games became harder. Two children wrote 'the games were my favourite' or 'because I like those (games) so much'. Other reasons listed by children were: game was fun, they can 'get the star', the game was fast, or because they liked typing all the numbers.

#### 6.2.3.4 Children's attitude towards whether the online game improved their mathematics

Twelve of 15 children said that they thought the games improved their mathematics. They listed the reasons of why they said that:

- because they learned more sums and got more practice and became faster
- because they were able to do all of the games
- because they found the mathematics easier
- because the games were a wee bit harder now
- because they could concentrate
- because if they can't get the right answer at first, they can get it correct the second time
- because the game became easier after playing more games

Three children chose the response ‘No’. Two of them thought the games were not very hard and one child reported that he had not learned anything.

#### 6.2.3.5 Children’s attitude towards whether they can work out answers more quickly through playing online games

Eleven of 15 children chose ‘Yes’ to show that they think they can calculate more quickly and only four of them responded ‘No’.

#### 6.2.3.6 Children’s attitude towards whether they would like to continue learning mathematics through playing games

Ten of 15 children chose ‘Yes’ to show that they would like to continue learning mathematics through playing games, and they reported that they would like to continue because: the games were fun; because the games were good; because the games were easy or because they liked the games.

Only five of the children responded ‘No’ because they thought the games were not fun or really hard or they did not like the games. One child reported that he thought the games were fun but he still didn’t want to do it again.

### 6.2.4 OBSERVATION

The researcher went to school and observed four children (one girl and three boys) playing games outside the main classroom area during the second treatment period. The teacher left the children in order to supervise the reminder of the class. Each child opened the online game homepage using IE very quickly because the online game homepage had already been added into the favourites list. Then each child put their own username and password to log on the game platform. All the children logged on the game platform in about one minute. From the observations it was found that although the corridor was very noisy with other children passing through, all the children were very quiet when playing the games, for the first five minutes. At about seven minutes, all the children were distracted as an adult came to use the printer nearby the computer, but three of them continued playing the game after watching a while. One boy became distracted and began to flick the table with his finger. He just opened a game and waited till the game finished, but he didn’t play it. At about thirteen minutes, all the children were distracted again and laughed because a school boy passed through the corridor and spoke to them. After that, two boys began to chat about the game while playing and watching the screen of each other (e.g. A boy pointed to another boy’s screen and said ‘I like this, I got past level two.’). But these two boys were concentrating on gaming for the last few minutes. A boy who always seemed to be looking at the screen and playing the game was not really concentrating on game playing, as he always played the games for a very short time then closed them without finishing, and clicked a new game. Compared with the boys, the girl was mostly quiet when playing the games, although she was distracted twice too. The game platform logged off automatically in 20 minutes according to the time when they logged in, a slight difference between each child. All children then went back to the classroom.

From the observations, the researcher found three main disadvantages when pupils played games in the corridor:

- It was occasionally noisy in the corridor
- It was easy to disturb the children because people often pass by there and the printer was just beside the computers. People often came to print.
- There was no teacher supervision

Together these factors above suggested that the children did not really engage with the game as well as they might have done.

### 6.2.5 INTERVIEW

In order to investigate the perception of the teacher about using online mathematics games in the classroom, the researcher did an interview with the teacher at school. See the appendix O for more details about this interview.

The teacher said it was difficult to say how well the children were achieving because she had not seen the results, but she stated that in her view children had grown in confidence with their addition and subtraction. In addition, because children focused on playing mathematics games for 20 minutes each day for six weeks, she believed that children were going to improve their ability.

The teacher reported that she stayed in the classroom with the paper-pencil card game group and two children on the online computer game but the rest of the children played the online game outside the classroom by themselves. Sometimes a support teacher would be there. On my observation I did not see a support teacher. In order to make sure children can play the online game by themselves, the teacher chose two children who had trouble in mathematics calculation, or had behaviour issues, to play the game in the classroom. The teacher stated that two children played the online game in the classroom for all the 17 sessions and some of the other children played in the classroom depending on their concentration. Because the teacher stayed in the classroom for all the sessions, she reported that she didn't know whether the online game group children outside the classroom engaged with the games task or not. But she stated that she helped the written work group children stay engaged and she knew the speed of the written work group by checking their written work. For the online game group in the classroom, she reported she did not monitor them so closely but they looked engaged. She said 'I thought they were engaged but that is not say they were doing more' because maybe 'on the computer they could go to any place but looked engaged' and 'they might be working at a slow pace'. She commented that 'there was no written evidence of the speed (with online game) where I have evidence of the speed with the jotter work.

The teacher reported that she would mark the worksheets of jotter work after they finished and give them their score. Children would know how many they got correct. The teacher stated that the written group children were trying to match the score or get more next time. If she found a child always made a repetitive mistake with the same problem, she would tell the children how to solve the problem directly before the next day. In contrast, the online game group children were keen to see what they had done but due to the technical problem the children couldn't access the information. The teacher said the children were 'disappointed' because they can't see their score on the computer but 'they were keen to see what they have done.

The teacher reported that children had some difficulties in the first week of doing this project. They had the problem of how to log on to the game platform, how to play the game and the teacher had to go to the corridor and tell the children that 20 minutes was over because the children didn't realize. The teacher reported the problem to the researcher promptly and the researcher fixed the problem after two days. The teacher reported in the interview that after solving the problem, she didn't need to go to the corridor because the game platform then logged out automatically and children came back to the classroom by themselves.

In the classroom, the teacher stated that she did not allow the children to speak to each other when playing the games or doing jotter work. The game play children sometimes put on the headphone or turned the volume off. If anybody had questions or was stuck, they could ask for help. But the teacher found fewer children in the classroom were stuck when they were playing the games except in the first few weeks. In the first few weeks, children had many questions about how to play games. This is probably because there was no introduction session about how to play games for the children. In the corridor it is difficult for children to get help from teacher. The teacher reported that she could not see any competition or cooperation between children at this point.

The teacher stated that she would not use the game for teaching but she would like to use the game for practice or reinforcement of learning. She said ‘in the future I will not use computer game to deliver the teaching but allow the computer for reinforcing teaching, for practice for learning’. And she stated that she would use the textbook and computer game together for reinforcing the teaching. She said the written work was necessary because of parents’ expectations, and other reasons related to school records. She explained by using an example of a child who has a reversal problem. She said: ‘it is good to get children to do written work because I need to see, physically see, whether she has corrected the problem, but it is not possible to see the problem on computer.’ In this case, the computer can’t diagnose it but the written work can pick it up. But she mentioned that if the technology improved, like Nintendo’s which allows users to write on the screen, she’d like to replace the textbook.

The teacher reported some shortcomings of the online games. She stated that children cannot improve their mathematics using some games, because they involve too much guess work. As she said: ‘children always click, click, click to choose a right one’ and it becomes trial and error. Also, some games don’t allow children to get instant results to let them know if they are right or wrong. She referred to the problem with the online game not telling players their performance: ‘it’s pity that children can’t review all their game performance’. She mentioned a boy when he did the paper-pencil mathematics card game. He tried to do better because he was keen to get through and get them all done. He was happy when he did. If children can review their game performance they will try to do better or try to solve more problems. Finally, the teacher pointed to a weakness related to the interface design of the games. She said that because the interface background will not change according to children's level – 'everything looks the same' – children did not realize how well they had done. She stated that the game interface should make children know exactly that they had moved to the next level or they had worked out faster.

**6.3 DISCUSSION**

Study three aimed to investigate whether classroom use of online mathematics games could influence children's learning and mathematics attitude. Very importantly, it was different from almost all studies conducted so far because it had a control group who had the same type of content and learning processes – but not using digital technology. This means that any differences in patterns could be put down to the technology: the nature of the online delivery.

The experience of working with the online mathematics game for 17 sessions over a 4 week period had no significant difference in both accuracy and speed of computation, and number attempted. The findings seemed to suggest a similar trend with some prior empirical research such as those reported by Ke (2008b) and Boticki et al. (2010) indicating that using the games made no significant difference to mathematics achievement. But it has to be remembered that (as reported earlier) many other studies have shown gains. It is necessary to look for possible reasons for the differences in findings. Characteristics of the sample, and the nature of the intervention, could be factors. As discussed in study two, with the mobile phone game (see Chapter Five Section 5.3), the fact that only a small number of children were involved and the short length of time playing seemed to be the possible factors that there was no significant difference for this online game study.

In addition, implementation fidelity could be a factor in the current study. The observation data indicated that when children played online games outside the classroom, without teacher supervision, they might not be fully engaged. In this case, the corridor was too noisy, making it easy to be disturbed. Moreover, the class teacher tended to stay in the classroom, and the observation data showed some children were chatting with others instead of playing the game because there was no supervision.

In this study, one key finding was that there were significant gains for the students who did the similar cognitive process in the form of a card game. Unlike the computer-game group, the paper-pencil card game group was closely supervised by the class teacher in the classroom and the teacher stated that she would help the activity group children stay engaged. There are many studies to confirm that student engagement such as involvement, time on task or quality of effort will be linked to positive outcome (e.g. Astin, 1984, 1999; Prensky, 2001; Gee, 2005). The differences between the two sets of results may point to the importance of the *environment* in which the learning takes place – whether it is computer-based or not.

Another key issue is challenge. Challenge is one of the key characteristics of an engaging game (Prensky, 2001; Jones, 1998). Due to the technology problem, the children were not able to check the history score of their playing and know their best score. In addition, because of a problem with the game design, the teacher stated that it was difficult for children to realize they had accessed a higher level, because they only saw the same game background. So when children played the game, they could not try to beat their own highest score and maybe they did not know they had jumped to a higher level. All these might affect the level of challenge and therefore affect how engaging children found the game. In contrast, for the paper-pencil card game group, the teacher said she would mark the children's worksheets and give them their score after they finished. The teacher also stated that she told the paper-pencil card game group children to try to match the score or get more next time. By doing this she was supplying extra challenge to engage the paper-pencil card game group children to take a look at the former result and try to beat it. It may be that the high engagement may be a reason for the stronger performance of the paper-pencil card game group.

In addition, it was found from observation that no children appeared to be reflecting on their mistakes during game playing, and so learning lessons for not making the same mistake next time. Most times, when the screen presented a ''wrong" message and indicated a right answer, students only expressed their feelings such as "oh", "come on" and moved on straight away. There seemed little time spent on reflective learning.

The game displayed a performance score only after each playing, with not enough feedback on the process. So children might not be able to reflect on their performance. Reflection is an essential element of learning (Kolb, 1984) and 'a major knowledge-construction format for game based learning' (Gee, 2003; cited in Ke, 2008b, p.1615). However, compared with the online game group that got little feedback from game program, the teacher reported that she would mark the paper-pencil mathematics activity group children's worksheets and give them their score quickly after they finished. Then, if she found a child made a repetitive mistake with the same problem, she would show the wrong solution and tell the children how to solve the problem directly, before their next day's play. This would help children to reflect on the experience so that they know how to avoid making the same mistakes again. A key message is that "learning by doing must be coupled with the opportunity to reflect and abstract relevant information for effective learning to occur" (Garris, Ahlers & Driskell, 2002, p. 455).

One interesting issue which comes from the findings from the teacher's interview needs to be discussed here. She stated that some games have too much guess work which leads to random clicking. One type of online flash game which was used in this study was using a mouse to click the right answer buttons on the computer screen from multiple-choice items (see example in Figure 6.1). If the children just clicked the screen randomly without being cognitively engaged, children may not have quality learning (Ke, 2008b). In comparison with the studies by Miller and Robertson (2010, 2011) which found positive learning outcomes, the authors conducted their studies by using the games Dr Kawashima's Brain Training Game on the Nintendo DS Lite system. Here children had to answer the questions by inputting the answer within the game. This kind of game-user interaction interface design would prevent random clicking and guessing, thus it will help to assure children are cognitively engaged and it may guarantee positive effect on children's performance.

Although we cannot claim that the online game has improved children's performance, the findings show the benefit of the research design in this study. In previous studies, including studies such as Miller and Robertson (2010, 2011) or Main and O'Rourke (2011), the authors compared their treatment groups with a non-treatment group. It could therefore be argued that their gains were, at least in part, due to practice effects.

One previous study did employ similar methodology; this was Shin, Norris, and Soloway (2006) who investigated the effectiveness of using a handheld game on Gameboy for fifty primary two children's mathematics learning. They compared their experimental group with a control group who used a card game with similar mental processes. The authors found that there was a significant difference in the mathematics scores after intervention in the two groups, and the handheld game group outperformed the card game group. The differences between Shin et al. (2006)'s study and the current study may be due to the different type of game, the different card game used for the control group or the different sample and sample size. However, an important factor in Shin et al. (2006)'s findings – and a possible flaw in their design – may have been the different length of treatment of their two groups. In that study, the game group children did 15 minutes 5 times per week for the first 10 days and then changed to 15 minutes 3 times per week. But the control group children did the card game only 15 minutes 3 times per week for the whole 5 weeks, so they had less time practising the processes. Moreover, the control group had to make a team with two children and each pair did the card game together with one child asking questions and the other answering. Actually then, the card game group children shared the 15 minutes with his/her team member. So not only did they have less time overall, the total treatment time of card game for each individual in the group was less than the game group. Therefore the performance of the game group may have been better than the control group simply due to the difference in treatment time.

Moving on to attitudes, students in this study seem to have a more positive attitude toward mathematics after the treatment of the online flash game. This finding was consistent with previous studies (e.g. Ke & Grabowski, 2007; Ke, 2008a, 2008b) that electronic games have a positive impact on mathematics attitude. However, the result of this study was different from the previous study using the mobile phone game, described in Chapter Five. In the mobile study, the finding showed there was no significant difference after mobile phone game playing. As discussed in Chapter Five section 5.3, one possible explanation for the lack of positive impact was the omission of a key motivation component - appropriate difficulty level. To keep children enjoying playing, the game must be neither too difficult nor too hard (e.g. Malone, 1981; Prensky, 2001; McFarlane et al., 2002). In this study all the online games were designed according to the children's different mathematics ability. The appropriate challenge level of this study seemed to have a positive effect on children's motivation which can be found from the significant improvement in the mean score for motivation.

In summary, there was no significant difference in performance after playing the online mathematics games. However, the findings may have been influenced by factors such as a small sample size and weakness in some aspects of the online mathematics game design. Moreover, the fact that children played online mathematics games in the corridor, with many distractions, may have interfered with the optimal experience of flow (Csikszentmihalyi, 1975, Csikszentmihalyi, 1997). Flow requires focused concentration and immersion in an activity. It is important to “avoid distractions and disruptions that intervene and destroy the subjective experience” (Norman, 1993, p. 35).

In addition, this study confirmed previous studies (e.g. Rowe, 2001; Shin et al., 2006) that non-electronic mathematics games activity can produce effective learning. The effectiveness of this kind of activity seemed to be associated with appropriate challenge and having feedback and reflection. So the teacher should support the interactive experiences with children such as setting goals or providing feedback to help ensure children are engaged, and these points should be incorporated into good game design too.

# CHAPTER 7 GENERAL DISCUSSION

## 7.1 INTRODUCTION

This chapter will describe some key issues that emerged from the three studies in this thesis. It will then review the results according to each research question by considering the key points on implementing games in the primary school classroom to improve children's mathematics learning. Finally, the limitations of this research will be discussed.

## 7.2 KEY ISSUES WHICH EMERGED FROM STUDIES

A feature which was investigated on several occasions was the idea of challenge. Challenge is a key aspect of motivation (e.g. Malone, 1981; Malone & Lepper, 1987; Csikszentmihalyi, 1997; Prensky, 2001) and games are more likely to be effective when they gradually increase the difficulty level of the game challenges (e.g., Garris, Ahlers, & Driskell, 2002; McFarlane, Sparrowhawk, & Heald, 2002). The findings of study one in this thesis indicated that children were motivated to play games by the process of challenge – such as 'getting a high score' or 'getting a higher level'. However, this was not ranked as highly as other reasons. The interview data of children and the class teacher from study two and study three did point to the importance of challenge. While acknowledging the mixed finding here, children tried to get a higher score and this motivated them to continue playing.

Providing the optimum level of challenge is important for motivating children to continue to play the game and enhance their learning. If a game that has too much challenge is seen as too difficult, the learner may have lower confidence or feel hopeless and quit trying, which leads to a decrease in motivation. But if the game is too easy, then the player may become distracted and lose interest. Designing the right level of challenge of the game task for players is critical for keeping players engaged and for learning to occur. In this thesis, the level of challenge in the online game was suitable for the participants because the game was designed according to the children's mathematics ability level, In contrast, the mobile phone game study indicated that the mobile phone game 'brain challenge' may have been difficult for some children, but they still reported they wanted to get a higher score. This aspect will be revisited in the next chapter.

Van Eck (2006) stated that in general educators have adopted three approaches for integrating games into the learning process: students design the games, educators and/or developers build educational games to teach students, or teachers can integrate commercial off-the-shelf (COTS) games into the classroom. In this thesis the online game study was using the second approach and the mobile study adopted the third. The findings of this study indicated that an easy-to-use interface of a game can help children grasp the game quickly. But when using the existing commercial game to support children's learning, the challenging level of a game should be matched with students' competency level. When designing a game for children's learning, a carefully designed game-user interface is also important. For example, the user response format in games should not be multiple-choice items that enable random clicking. Also, there should be a clear game feedback interface for children, which comes through alerts, scores, rewards or game progress reports which can track students' progress to motivate children to continue practising until they achieve the game's learning goals. Therefore children can be motivated by the challenge of a game – but a well-designed game with an optimal level of challenge is the key aspect to keep players engaged with high level of motivation. It encourages them to continually practise their skills in order to have effective learning.

In addition, reflection is an essential element of learning (Kolb, 1984) and "learning by doing must be coupled with the opportunity to reflect and abstract relevant information for effective learning to occur" (Garris, Ahlers & Driskell, 2002, p. 455). So the clear game feedback interface for children should also include clear game playing report after children's game playing. For example, the report should display the mistakes during children's playing, especially the repetitive mistake with the same problem and display the solutions for children. This would help children to reflect on the experience so that they know how to avoid making the same mistakes again.

In this study, one key finding was the importance of the treatment period. This study found that there were significant gains for the students who did the six weeks intervention rather than three weeks. Looking at some prior research, such as Miller & Robertson (2010, 2011) which indicated that the games made a significant difference in mathematics achievement, the intervention time was nine weeks or more. In contrast, Ke (2008b) found no significant difference in mathematics performance after the game intervention of five weeks. It may be that there is a threshold effect with time, and perhaps a longer time game-playing could have more significant effects on mathematics performance beyond those found in this study. However, this is an area where we need more studies and more evidence to justify the length of the treatment period.

Moreover, the *environment* in which the learning takes place is also important – whether it is computer-based or not. This study found that there were significant gains for the students who did the similar cognitive process in the form of a card game. One factor may have been that the teacher created a good learning environment for this. The children worked in the classroom and the teacher made sure of this by reducing distractions and monitoring their progress. Student engagement such as involvement, time on task or quality of effort will be linked to positive outcome (e.g. Astin, 1984, 1999; Prensky, 2001; Gee, 2005). In contrast, the level of engagement in the computer game was not closely monitored and there were distractions for the children working in the corridor (see section 6.2.4). The quality of the learning environment where children play computer games is something that is not often mentioned in research reports but it may be a factor which needs to be taken account of.

Comparing the scores of answers correct in pre-test and post-test was a common research method in previous research for judging children's performance after using games for their learning. However, in this thesis the researcher compared the number of questions attempted by children, as well as the answers correct, in the pre-test and post-test. The increase in questions attempted by children in study two and study three indicated that children responded to the challenge during the test. Thinking about the development of autonomy, it is a good thing for children's learning if they are willing to try to 'have a go'.

In research, the ecological validity of a study means that the methods, materials and setting of the study that is being investigated must approximate the real-world (Brewer, 2000). If a study was done outside the regular classroom (e.g. Laffey et al.,2003) or students were taught in a segregated classroom (Vogel et al., 2006b) or other conditions were imposed which were unlike a 'normal' teaching situation, the study would have low ecological validity because the results cannot be generalised to the real classroom. The studies in this thesis have high ecological validity as they were conducted in the classroom with the regular class teacher within regular class time. Although the findings in this study are specific to the one context, because of the high ecological validity of the study it is more likely that we can generalize the results to other primary classrooms.

## 7.3 A REVIEW OF RESULTS AND RESEARCH QUESTIONS

There were three main research questions which were addressed in this thesis.

Q1. What are the views of children in Scotland and China about electronic game playing?

The study investigated the views of children in Scotland and China about their game playing, such as time spent on games, favourite game type, who they liked to play and discuss with and why they liked playing electronic games. The findings of this study have helped to fill a gap in the literature about children's views on game playing in a cross-cultural context, in Scotland and China. These will be further discussed below. The results indicated that there were some gender differences between boys and girls which were consistent with previous research (e.g. Philips, Rolls, Rouse, & Griffiths, 1995; Buchman & Funk, 1996; Fromme, 2003). For example, more girls report liking playing games with other girls than boys do. An interesting finding here, from the survey of Scottish children, was that girls were significantly more likely to be taught games by boys than boys themselves were. This seems to suggest that girls tend to see the boys as the game ‘experts’. This finding can be useful to teachers when they tried to integrate games into the classroom for learning. On one hand, the findings suggest that teachers can encourage boys to help girls to play the game. This informal peer tutoring can bring benefits to the boys, who are taking on a responsible role in the classroom. Peer tutoring has been shown to be an effective approach to learning and teaching in primary schools (Topping, 2001) and have positive gains in mathematics attainment (Topping, Miller, Murray, Henderson, Fortuna, & Conlin, 2011). Although the findings from the current study pointed to boys tutoring girls, Rohrbeck, Ginsburg- Block, Fantuzzo, and Miller (2003) did a meta-analyses study of peer tutoring and found that same-gender grouping strategies appeared to produce more positive impact than mixed-gender group. Therefore it would be valuable to explore different types of peer tutoring arrangements. Certainly, while it is good that boys take on this tutoring role, it is important that teachers make girls believe they can be ‘experts’ as well.

This study has also found some difference in patterns between Chinese and Scottish children in their electronic game playing, such as Scottish students spending much more time on gaming while Chinese children did not seem to play games frequently or spend much time on gaming. Also there was no significant gender difference in the time spent playing electronic games for Scottish children but electronic games are played more by Chinese male students than by females. Electronic games research is at an early stage in the Chinese education system. Currently in China, teachers must complete the task of teaching in their curriculum with text books and no teacher would be expected to use electronic games in class unless they become part of the curriculum (Anyaegbu, Ting, & Li, 2011). Teachers are often reluctant to use electronic games in the classroom because of concerns over their own efficacy in using them, and anxiety about possible failures is a major obstacle (Purcell, 2005).

This study showed that one of the important motivators for Chinese children was that they can learn from games, so the results have the potential to encourage Chinese mathematics teachers to employ electronic games in mathematics learning in primary schools. The Scottish Government has already produced a new curriculum known as the Curriculum for Excellence (CfE) in 2004 (Scottish Executive, 2004). The CfE encourages young people to 'think, question, research and work together rather than being passively fed information using traditional learning approaches' (Razak, Connolly, Baxter, Hainey & Wilson, 2012, p.402). This new curriculum promotes active learning, including the use of digital games-based learning technology. In Scotland, Learning and Teaching Scotland has actively promoted gaming in schools, including funding a games and learning centre for CfE (Groff, Howells & Cranmer, 2012). In the UK as a whole, Williamson (2009) found 35% of interviewed UK teachers had already used computer games in their teaching and 60% of teachers would consider using computer games in their teaching in the future. As China develops its education system, more teachers may be encouraged by the research evidence to use games, and consequently game learning may also be put into the curriculum. Although there may be some difficulties, for example, China is still a developing country, and as the study found there are still some Chinese children (14%) who have not played electronic games before. But the set of ideas presented in this thesis may encourage and stimulate Chinese teachers and policy makers' thinking about using electronic games for Chinese pupils' mathematics learning.

Q2. What is the effect of a mobile phone game on children's mathematics learning?

The research into using mobile phone games in the classroom suggested that mobile phone games can positively influence children's speed and percentage accuracy rate in a mathematics test after six weeks game playing. The results of this study have added to our knowledge about game based learning, in that a low cost, and relatively unsophisticated programme can bring benefits for children's mental mathematics calculation. Moreover, the results can encourage the Chinese teachers or the teachers from other countries to use mobile phone games in their classroom because of the lower costs involved. For example, in China the number of students in one class is over 50, so it is possible to have so many mobile phones instead of computers within a classroom.

Q3. Does an electronic game improve children's performance and attitudes when maths content and process are controlled for?

In relation to performance, the answer to this research question is no; the findings of study 3 did not allow us to say that the electronic game improved performance when content and process are controlled for. Indeed, no significant differences were found in students' mathematics performance over time as a result of the online game. Taking into account many studies published to date, this was a surprising finding. On one hand, this could be because the more sophisticated research design in the current study has helped to highlight weaknesses in previous studies. On the other hand, there may be reasons why the current study showed no gains from the electronic game; these may be related to the research design, implementation factors or the nature of the game itself. The non-significant result may be due to the small sample size and short intervention time (see earlier discussion about previous published research section 5.3 & 6.3). In addition, the students may have disengaged or been distracted from game play, possibly because they played the game outside the classroom without the teacher's supervision. Moreover, the game itself may have been a factor. As discussed above, challenge and feedback are important game attributes for effective learning and these were questionable in the online game. There may also have been some shortcomings in the game design, such as children being able to progress by random clicking. In contrast, although paper-pencil based mathematics games cannot always provide an immediate and highly motivating level of feedback, the teacher in this study took this role and tried to give the children feedback as quickly as she could and encouraged children to achieve more next time (a new challenge). The traditional paper-pencil based game can be applied in the classroom with good teacher support in order to enhance the quality of students' learning.

However, the second part of this research question can be answered more positively. This study found that children's mathematical attitudes significantly improved by using the online game, whereas this was not true of the paper-pencil based card game. This should be seen as a positive feature, since if children feel positive about mathematics, they are more likely to engage with it in the classroom. Overall, in relation to this research question, I believe that more research is needed that provides a clearer picture of their true impact because of the confounding factors in this experiment.

**7.4 LIMITATIONS**

There are a number of limitations that should be noted associated with this study.

First, a point that has been made several times is that the sample size is small in all of the studies. The questionnaire data of children's electronic game use and attitudes towards electronic games for this study was gathered only with a total 44 students (21 students in questionnaire one and 23 in questionnaire two) in an urban primary school which was located in the east of Scotland and 127 pupils from two primary schools in South of China. These were convenience samples, not representative samples. The generalization of the results is limited to similar populations in Scotland and China. In addition, the sample sizes for experimental studies in this thesis which were conducted to find out the effectiveness of electronic games were also small. Again, as with the questionnaire studies, the findings cannot be generalised from the experimental studies to other classes or schools because of the characteristics of the involved school. It is a small school with a very good reputation, is located in the east of Scotland, the sample children included a high proportion of male students, there was a limited number of computers in the classroom and the participant class teacher was very knowledgeable – she had previous experience of using Nintendo games for children's mathematics learning. In spite of this, the findings may be similar to many other Scottish school conditions because the children have the same mathematics curriculum and teacher was trained in the same Scottish scheme.

Second, the effectiveness of using games in the classroom in this research may have been affected by the online game intervention not being implemented as planned. For example, they did not have enough computers in the classroom, so some children could not play the game inside the classroom, according to the initial plan. Also, according to the mobile phone game study plan, children needed to play the games for three weeks, but some children missed one or two days' game intervention due to absence or other school activity. So the time spent on games was reduced. This may be a factor influencing the positive effect on children's learning.

Third, one methodological weakness of this study is the design of questionnaire in Scotland and China. The consistency of questionnaire used in Scotland and China needs to be considered to ensure the reliability of research design. The questionnaire used for Chinese pupils was not exactly the same as the Scottish students. This was because the questionnaire had to be adapted. The length of time for finishing the questionnaire was limited by the Chinese teacher's tight class schedule and some questionnaire items were changed according to the Chinese teachers' opinions. But most of the questions were the same.

Fourth, when designing questionnaire items, the researcher put some examples of games to help children understand some concepts or phrases. For example, the researcher listed some games, for example 'Save Cinderella' and 'Study in a fairyland', which were famous educational games in China to help children understand the concept of 'educational game' used in the questionnaire (See Appendix C). However these examples might not be sufficient for students to have a good understanding of what 'educational game' was and may have led to some misunderstanding, for example that only 'Save Cinderella' and 'Study in a fairyland' were educational games. In spite of this, because no children asked for clarification or help, from the researcher's perspective this maybe was not a significant problem.

# CHAPTER 8 CONCLUSION AND FUTURE WORK

## 8.1 INTRODUCTION

The purpose of this thesis has been to investigate primary school children's views about playing electronic games and to examine the effect of using electronic games for children's mathematics learning. This last chapter of the thesis presents a synopsis of the doctoral research, which includes the key findings from the three studies throughout the doctoral journey and lists four sets of implications, for academic researchers, primary school teachers, game designers, and educational officers and teachers in China. Following this, my personal reflections on my PhD study is provided. The thesis ends with a discussion of directions for further studies.

## 8.2 RESEARCH FINDINGS FROM THREE STUDIES

Three studies were conducted in this thesis. The research started with a study which explored primary school children's electronic game use and their attitudes towards electronic game playing. The following two empirical studies were conducted to examine the impact of a mobile phone game and online flash games for children's mathematics learning. The mobile phone game study was designed to see if a low-cost game could bring benefits that have been associated with more expensive game consoles, while the online flash game study compared the experimental group with a group using the same cognitive processes, not on a computer but playing a paper-based card game. The following are the key findings.

<u>Study One</u>:

1. Electronic games playing is very common for both Scottish and Chinese children and they have positive attitudes towards electronic games playing.
2. Both Scottish and Chinese students seemed to be more motivated by the fun aspects of the games most.
3. Chinese boys reported spending more time per day on playing electronic games than Chinese girls but this was not the case with the Scottish sample.
4. Scottish children spent more time on gaming than Chinese students.
5. The gender differences in Scottish children's choice of favourite games were not statistically significant, so we cannot say that the Scottish boys and girls preferred different types of games. On the other hand, the differences between Chinese boys and girls were statistically significant, so we conclude that they did prefer different games.
6. Girls prefer playing computer games with girls. This was true for both Scottish and Chinese students. Chinese boys like playing with boys but the picture was less clear-cut for Scottish children. One notable finding was that the Scottish girls were significantly more likely to report being taught by boys than boys themselves were (the study did not address the same question for Chinese children).
7. Both Chinese and Scottish children reported mixed views about their parents' attitudes towards their electronic game playing.
8. Chinese children are more likely to agree that they like playing electronic games alone but Scottish children tended to disagree with this.
9. Scottish children tended to regard games primarily as a source of enjoyment and for entertainment while games seemed be a learning medium besides fun for Chinese students.

10. Scottish children did not spend a lot of time on playing mobile phone games.

Study Two:

The findings provide evidence to show a positive effect in speed of computation and percentage accuracy rate after playing a mobile phone game over a 6-week period but not over three weeks. However, no significant difference was found in mathematics attitude after playing the mobile phone game. In addition, the children's game record sheets indicated that the mobile phone game 'brain challenge' seemed to be a bit difficult for some children and may have prevented some children having more positive benefits.

Study Three:

The results suggested that the online electronic game had a positive impact on children's mathematics attitude while that was not true for the paper-pencil based mathematics card game. However, in terms of performance a different picture emerged; the improvement in children's mathematics performance from the card game was significant. In contrast, no significant gains were found in students' mathematics performance after online flash game playing. When a between-group analysis was conducted, there was no significant difference between the two conditions. Taken at face value, this is an important finding and runs counter to many previous studies. However, there are some concerns about treatment fidelity- the extent to which the children actually did what they were meant to do (See earlier discussion in Chapter Six section 6.3). One possibility is that some of the students may have been distracted from game play because they played the game outside the classroom without the teacher's supervision. This is further discussed below.

## 8.3 IMPLICATIONS

### 8.3.1 IMPLICATIONS FOR ACADEMIC RESEARCHERS

There have been many published studies to investigate children's views on electronic game playing worldwide (e.g. Fromme, 2003; Roberts, Foehr & Rideout, 2005, 2010; Pratchett, 2005; Ofcm, 2005, 2012). The findings of this thesis add a picture of how Scottish and Chinese children use video and computer games, what games they play, who they play with and the reasons for gaming. As such, it adds to the literature about children's game playing in a cross-cultural context. However, with the current pace of change in China, this situation may change very rapidly and more research here will be important.

Few prior studies had been done using mobile phone games. This study has added to knowledge here by suggesting similar results to studies using expensive game consoles. It has also pointed to some surprises. One of these related to the fact that no significant difference was found in children's mathematics attitudes after using the games. The mobile phone game 'brain challenge' seemed to be a bit difficult for the sample primary 4 children. More research matching available mobile phone games with children's interest and ability level would be worthwhile.

Similarly, very few studies have compared the impact of technology-based online flash game with learning the same material in a non-digital way (in this case, using a paper–pencil based card game) in the primary school classroom. The key issue here is that the comparison group children were using the same cognitive process. In this study the gains from the controls were significant but the gains for the online game group were not. This shows the value of the research design. Future research should reconsider the nature of control or comparison groups. As noted in the literature review, several studies into game based learning have not had control groups. Those that have done so have usually employed no-treatment controls, rather than children doing tasks which involved similar cognitive processes to those of the experimental group. These results suggest that when the cognitive demand is controlled for, the difference in performance between electronic games and other ways of learning may not be clear cut.  For future research, there may be a case for having two comparison groups: one which has similar cognitive experiences or similar learning material, and also a no-treatment control group.

Moreover, this study collected some data, such as children's mobile phone game record sheets, to be used as a check on implementation fidelity. In the future, researchers should collect more process data, to ensure that the children have actually done what they were asked to do. Some previous studies either used quantitative (e.g. Miller & Robertson, 2010, 2011; Main & Rourke, 2011) or qualitative methods (e.g. Costu, Aydin, & Filiz 2009; Boticki, Looi, &Wong, 2010) to conduct their study. A mixed methods approach as used in this research could be developed to provide valuable insight to understand and explain the process as well as the products of the studies.

Finally, the mathematics attitudes scale created for this study could be used as a research tool to assess children's mathematics attitudes in the future because of its high reliability as demonstrated by the Cronbach's alpha co-efficient test scores.

### 8.3.2 IMPLICATIONS FOR PRIMARY SCHOOL TEACHERS

The results of this study, with some positive results from using mobile phone games and an online flash game, can encourage other Scottish primary school teachers to use these two kinds of games for supporting children's mathematics learning or their attitudes towards maths. The findings may also be of interest to primary school teachers in other part of UK. Teachers will be able to use the mobile games knowing that they can help their children in mathematics, although there are some things to consider. An unanticipated finding with the flash game that will be of interest to teachers is that a well-designed card game can have similar results to electronic games. In some ways this moves the focus away from electronic games towards game playing in general, and what teachers can learn from the cognitive and motivational processes involved.

From the results of this thesis, there are some issues for teachers to consider before using electronic games in the classroom for learning. First of all, a teacher who is looking to implement an electronic game in a primary school classroom must be able to find a game with an optimum level of challenge that fits with the children's ability to solve the problems in the game. This requires the teacher to have a good knowledge of the range of games that are available. It also means s/he has to have a good understanding of the levels his/her children are working at, and also what motivates them. As mentioned above, the mobile phone game in this research seemed to a bit difficult for some primary 4 children. Despite this, it produced some positive results. The online game and card game were designed according to the children's ability, thus the challenge level was closely matched with the primary 3 children.

Secondly, it will be important to ensure the environmental conditions are favourable for learning to happen. The findings of study 3 suggested that environmental interference (e.g. children stopping playing because of distractions around them) may cause children to disengage and then may hinder the effectiveness of using the game for learning. It may not be safe to assume that electronic games will keep children's attention at all times, even engaging ones. So the teacher needs to make sure that the children's game playing is under his/her supervision and without interruption when children are involved in game playing. Similarly, the teacher needs to make sure of children's engagement when using non-electronic games in the classroom. In addition, it will also be important for the teacher to give feedback quickly for non-electronic games because children do not necessarily get feedback from the game itself. Third, there is an extra issue for teachers if they are using commercial games (COTS games) for learning purposes. The teacher has to know "not all games are appropriate for use in school, and of those that are, not all lend themselves to meaningful educational use. Appreciating their educational potential involves appraisal in two respects: first, deciding what is inherent in the game that is of educational value; second, being aware of the range of developmentally appropriate learning activities for which the game may serve as a catalyst" (Miller, Robertson, Hudson, & Shimi, 2012, p.245). Lastly, the teacher needs to get support from the school to have enough game systems to use in the classroom as well as technical support such as configuring the computer for playing online games.

### 8.3.3 IMPLICATIONS FOR GAME DESIGNERS

The findings of this thesis offer some key points for game designers in different countries to consider when developing games for use in the primary classroom.

Feedback provided to players is important in effective learning (Cameron & Dwyer, 2005). Games can provide feedback through various formats: alerts, scores, rewards or game progress reports. The class teacher in this study claimed that a progress report is important, as it enables children and the teacher to track the students' progress to motivate them to continue practising to do better next time. Due to a technical problem, the game history could not be displayed in this research. Moreover, children did not even know they had made progress to the next level because the design of the game background for each level was the same. These features may have affected performance. Therefore, possible game features that encourage children to achieve their learning goal, as suggested by the study results, can be: a progress report that motivates children to do more practising and a clear label for different levels to enable the students to know they have either passed or failed to move on to the next level. This will help children evaluate how their performance matched with their goal.

In addition, reflection is an essential element for game based learning (e.g. Kolb, 1984; Garris et al., 2002; Gee, 2003). It was found that the teacher helped the paper-pencil card group children reflect on their mistakes when they made a repetitive mistake with the same problem, but no children appeared to be reflecting on their mistakes during the game playing, which may be due to the weakness in the game design in this study. As discussed in Chapter Six, section 6.3, the findings of the study indicated that the game needs to give the feedback based on the student's correct or incorrect answers. If the game can demonstrate the number of answers correct and the questions which children make mistakes on, instead of a total score only, it can help children to reflect on the experience so that they know how to avoid making the same mistakes again.

An interesting issue which comes from the class teacher's interview as well is some games have too much guess work, which leads to random clicking to find the right answer from multiple-choice items (see example in Figure 6.1). So the game-user interaction interface design should prevent random clicking and guessing, and the user response format in games should not be multiple-choice items, in order to help to ensure children are cognitively engaged and maximize performance.

### 8.3.4 IMPLICATIONS FOR EDUCATIONAL OFFICERS AND TEACHERS IN CHINA

This study provides valuable information that could help educational officers and teachers in China to improve their pedagogical practices. The results of this study have the potential to encourage Chinese teachers to incorporate the use of electronic games in the primary classroom to improve students' achievement and attitudes. The evidence also means that educational officers can learn from this research and think of integrating electronic games into Chinese pupils' mathematics curriculum. The Chinese curriculum is very different from the Scottish one, although the purposes of the Curriculum for Excellence (CfE) might be valid in China too. The CfE promotes the use of digital games-based learning technology in the school and one of the reasons is that this technology is part of the children's world today. The questionnaire survey for part one of this thesis indicates it is for Chinese children too.

## 8.4 CRITICAL REFLECTION

The PhD journey taught me a significant amount about conducting education research. I picked up many relevant research skills from planning a study to presenting the findings. I believe that PhD study is a demanding and an expensive journey in terms of money and time, especially for me. Due to some family and personal reasons, my PhD trip took me a longer time than I expected and I had to travel between two cities. However, this PhD study is also a precious experience for personal professional development.

Now I have almost completed the thesis write-up, there is a sense of accomplishment of seeing the results of my work. The finish line is in sight. It is the right time to look back at those years to see the process that I have gone through. In this thesis, I have already written many words about my research (what I have done and what I have studied). At this point I feel I should reflect on the things I have learned that would be helpful at the beginning of the journey if I started again.

First, the right supervisor is very important. I'd like to say I am lucky because I had the right supervisors. During the difficult periods of the PhD journey, my supervisors provided support and asked critical questions which helped with my thesis building.

They encouraged me to look critically at the research that had been done in the past, and not accept it at face value. I learned from this and this helped me to look at both my own findings and the work of others more critically.

Secondly, when I started the study of PhD, I assumed that producing new knowledge would be the hard part and the methodology would be the easiest part, because I could adopt and follow a set of procedures already available in the literature. However, the further I have gone during my PhD study, the more I realise that the construction of knowledge and the methodology used are intimately connected. I have learned to look much more critically at previous studies – in particular the way that interventions were conducted, and the way that the methodology could have influenced the findings.

When I was at the literature review stage, most of the studies showed that electronic games can promote learning significantly. These positive findings may have influenced how I approached the interpretation of my findings. But in my study I got some non-significant results. At first I saw these as failures, as if I had done something wrong, but I later realised that a non-significant result is also important. It is a finding in itself, and the non-significant findings helped me to understand more about the processes of learning through game-based learning. I have become more careful about trying to be objective, and not make assumptions based on current trends. Also, some of the non-significant findings have motivated me to want to find out more. One example of this is the issue of the intervention period. In my mobile game study, I found children got positive impact after six weeks intervention but they did not show significant benefit after three weeks game playing. As discussed in 7.2, after looking again at previous studies and my studies, this raised a question about whether there could be a minimum time period for electronic game learning to take place. Moreover, through the PhD journey, I have learned to be more careful in differentiating descriptive and inferential statistics. I have become more careful in the interpretation of data collected, especially in reporting the findings of significance and non-significance. I increased my confidence and competence in data analysis and interpreting as well as presenting the results.

To be a self-motivated and self-directed learner is very important from the start to do the PhD. I found PhD study was unrelenting hard work for a quite long time. I learned the need to use time effectively and write the thesis from the start. Looking back, I did not always do this and became distracted by some personal issues. It is important to maintain a balance between study and family roles. It was not until last year that I learned how to develop more appropriate time frames for my writing. In the previous years I sometimes set myself the deadlines that I could not keep. This increased my stress and feelings of failure. So I learned you should take responsibility for setting your goals, having effective time management, and making steady progress in the research endeavour.

Finally, I also learned that it is important to develop positive attitudes towards myself and to the challenges during the long journey. “Don’t doubt yourself.” “Keep at it, don’t give up.” All these affirmations encouraged me and helped me to develop positive attitudes to the PhD study and will enable me to attain the finish line.

## 8.5 FUTURE STUDY

Following on from the findings of the study, future research should continue to investigate the impact of similar electronic games used in this study in the primary school classroom for children's learning with different populations and larger sample sizes. As noted in the implications, the small numbers in the current study may have been a factor in several analyses not achieving significance. The mixed results on the impact on children's mathematics attitude in this study necessitate further investigation into the effects of electronic games on attitudes. Moreover, positive impact on children's mathematics learning was found with a longer, six weeks game playing. Therefore the factor of the optimum length of intervention is worthy of further exploration.

Additionally, future studies should consider the factors such as children's individual ability difference, gender difference, and the nature of the control group used to control Hawthorn effects. In addition, the idea of peer tutoring has emerged from the findings of this research, as discussed in Chapter Seven section 7.3. Possible additional educational benefits for peer tutoring from using electronic games for learning need to be investigated in the future too.

Finally, the mobile phone game 'brain challenge' is a commercial game and was not designed for mathematics learning initially. This game has three other tasks, memory, visual tasks and logic, which may be related to other educational purposes. Besides this commercial game, we should be looking critically at the wide range of commercial games to see if – and how – they can be used in the classroom in the future.

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# APPENDIX

## APPENDIX I QUESTIONNAIRES IN STUDY ONE

This appendix includes the following sections:

Appendix A: Questionnaire One: Children's attitudes towards electronic games in Scottish sample

Appendix B: Questionnaire Two: Children's attitudes towards mobile phone games in Scottish sample

Appendix C: Questionnaire Three: Children's attitudes towards electronic games in Chinese sample (Chinese Edition)

Appendix D: Questionnaire Three: Children's attitudes towards electronic games in Chinese sample (English Edition)

APPENDIX A: QUESTIONNAIRE ONE: CHILDREN'S ATTITUDES TOWARDS ELECTRONIC GAMES IN SCOTTISH SAMPLE

University of Dundee

We are trying to find out which computer games/electronic games kids like, and how often they play them and who they play them with. Although we ask for your name we will keep your answers safe and will not let anyone know that they were your thoughts. If you want to know more about what we are doing then you can contact me on email at M.chen@dundee.ac.uk or look at our website at www.dundee.ac.uk/eswce/computergames

| First name | Surname | Class |
|---|---|---|
| | | |

| Name of School | Male or female | Date of Birth |
|---|---|---|
| | | |

| Number of brothers | Number of sisters |
|---|---|
| | |

List the names of your current favourite computer games/electronic games?

________________ ________________ _______________ ______________

________________ ________________ _______________ ______________

Tick the correct answer, tick only one box:

e.g. How often do you go to school?

A. every weekday ☑

B. at weekends only ☐

C. only in July ☐

How often do you play computer games/electronic games?

A. every day ☐
B. at least once a week ☐
C. once or twice a month ☐

When do you play computer games/electronic games at home?

A. mostly on weekends ☐
B. mostly on weekdays ☐
C. all the time ☐

How long do you normally play for per day?

A. under 30 mins ☐
B. 30 mins to one hour ☐
C. one to two hours ☐
D. over two hours ☐

Tick the box next to the game systems that you own. You can choose more than one answer.

A. PC gaming ☐
B. Playstation ☐
C. Playstation 2 ☐
D. Xbox ☐
E. Xbox360 ☐
F. Nintendo DS ☐
G. Nintendo DS Lite ☐
H. PSP ☐
I. Game Boy ☐
J. I do not own a game system ☐
K. Other system ______________________________

| For each statement, put a tick in one of the boxes on the 5 point scale to show how much you agree or disagree | Disagree | | Agree |
|---|---|---|---|
| | 0 | | 100 |
| *Example:* I like chocolate | | | |
| 1 I like playing electronic/ computer games | | | |
| 2 I like playing alone | | | |
| 3 I like playing with my parent(s) | | | |
| 4 I like playing with my brother(s) or sister(s) | | | |
| 5 I like playing with my friends | | | |
| 6 My parents like me play electronic/ computer games | | | |
| 7 I play electronic/ computer games when I don't want to do my homework | | | |
| 8 Friends come to my home and I play electronic/ computer games with them | | | |
| 9 I play electronic/ computer games when I'm bored | | | |
| 10 I play electronic/ computer games as often as possible | | | |
| 11 I like to study at school. | | | |
| 12 I like playing electronic/ computer games at school | | | |
| 13 I like playing electronic/ computer games alone | | | |
| 14 I like playing electronic/ computer games with parents, uncles, aunts, grandparents | | | |
| 15 I like playing electronic/ computer games with boys | | | |
| 16 I like playing electronic/ computer games with girls | | | |
| 17 Parents, uncles, aunts, or grandparents teach me to play electronic/ computer games | | | |
| 18 Boys teach me to play electronic/ computer games | | | |
| 19 Girls teach me to play electronic/ computer games | | | |
| 20 I teach myself to play electronic/ computer games | | | |
| 21 I talk about electronic/ computer games with boys | | | |
| 22 I talk about electronic/ computer games with girls | | | |
| 23 I talk about electronic/ computer games with parents, uncles, aunts, grandparents | | | |
| 24 I play computer games/electronic games because they are fun | | | |
| 25 I play computer games/electronic games because I want to defeat my friends | | | |
| 26 I play computer games/electronic games because they are exciting | | | |
| 27 I play computer games/electronic games because I learn from them | | | |
| 28 I play computer games/electronic games because I want to get a high score | | | |

Thank you for your help

APPENDIX B: QUESTIONNAIRE TWO: CHILDREN'S ATTITUDES TOWARDS MOBILE PHONE GAMES IN SCOTTISH SAMPLE

## Playing games on Mobile phones

We are trying to find out whether children have mobile phones, which kind of mobile phones they have and what they normally use them for. We are also interested in whether children play mobile games and like/dislike playing mobile games. Although we ask for your name we will keep your answers confidential and will not let anyone know that they were your thoughts. If you want to know more about what we are doing then you can contact me on email at m.chen@dundee.ac.uk.

| First name | Surname | Class |
|---|---|---|
| | | |

| Name of School | Male or female | Age |
|---|---|---|
| | | |

Q1. Do you have a mobile phone?

A. YES ☐ ☐
B. NO ☐ ☐ If you tick NO, please go to Q4

Q2. If you tick YES, could you please tell your mobile phone brand and model?

e.g. Sony Ericsson W810i

Q3. When did you get your own mobile phone?

A. This year ☐
B. Last year ☐
C. Two years ago ☐
D. More than three years ago ☐

Q4. Have you played games on a mobile before?

A. YES ☐
B. NO ☐ If you tick NO, please go to Q12

Q5. If you tick YES, could you please list the games that you have played before?

Q6. When do you play mobile games?

A. at school ☐ ☐
B. at home ☐ ☐
C. in the bus/car ☐

Q7. How often do you play mobile games?

A. every day ☐ ☐
B. at least once a week ☐ ☐
C. once or twice a month ☐☐

Q8. How long do you normally play for each time?

A. under 10 mins ☐
B. 10 mins to 30 mins ☐
C. 30 mins to 1 hour ☐
D. over 1 hour ☐

Q9. Do you like playing mobile games?

A. I do like playing mobile games. ☐
B. I sometimes like playing mobile games. ☐
C. I don't like playing mobile games. ☐

Q10. Have you downloaded game content for your mobile phone?

A. YES ☐
B. NO ☐ If you tick NO, please go to Q12

Q11. If you tick YES, can you remember the game that you downloaded?

For following questions you can choose more than one answer.

Q12. What do you normally use mobile phone for?

A. Make a call ☐
B. Send message ☐
C. Surf internet ☐
D. Listen to music ☐
E. Download music ☐
F. Play games ☐

G. Others ______________________________

Q13. On which game system(s) have you played electronic games before?

A. PC gaming ☐
B. Playstation ☐
C. Playstation 2 ☐
D. Playstation 3 ☐
E. Playstation Portable (PSP) ☐
F. Nintendo DS ☐
G. Nintendo DS Lite ☐
H. Nintendo Wii ☐
I. Nintendo GameCube ☐
J. Xbox ☐
K. Xbox360 ☐
L. Game Boy ☐
M. Mobile game ☐

N. Other system ______________________________

Q14. What kinds of games do you like playing?

A. Adventure games (e.g. Freddi Fish) ☐
B. Simulations (e.g. The Sims) ☐
C. Action games (e.g. Tomb Raider) ☐
D. Fighting games (e.g. Mortal Kombat) ☐
E. Puzzle games (e.g. Tetris) ☐
F. Role-playing games (e.g. Diablo) ☐
G. Sports games (e.g. FIFA 2007) ☐

H. Strategy games (e.g. Warcraft) ☐

Q15. Why do you like playing electronic games?

A. Because they are fun ☐
B. Because I'd like to defeat my friends ☐
C. Because they are exciting ☐
D. Because I learn from them ☐

E. Because I'd like to get a high score ☐

Thank you for your help

APPENDIX C: QUESTIONNAIRE THREE: CHILDREN'S ATTITUDES TOWARDS ELECTRONIC GAMES IN CHINESE SAMPLE (CHINESE EDITION)

本问卷旨在了解小学生对游戏的态度和喜好，了解小学生对教育游戏和手机游戏的一些看法。虽然本问卷会问及一些个人信息，但我们将会保证您的信息的安全性，不会让其他人了解您的想法，请您遵照事实认真填写，非常感谢！

| | |
|---|---|
| 学校： | |
| 性别： | |
| 年级： | |
| 年龄： | |

请在相应的选项上打“ √ ”

1. 你有玩过电脑游戏吗？
A 有　B 没有

2. 你喜欢玩电脑游戏吗？
A 非常喜欢　B 喜欢　C 一般　D 不喜欢　E 很不喜欢

3. 你多长时间玩一次电脑游戏？
A 每天　B 至少一个星期一次　C 一个月一两次

4. 你一般在哪里玩电脑游戏？
A 家里　B 学校　C 网吧

5. 如果你在家里玩电脑游戏，一般什么时候？
A 周末　B 星期一至星期五　C 任何时候

6. 一天中玩电脑游戏一般多长时间？
A 10 分钟以下　B 10 分钟到 30 分钟 C 30 分钟到 1 个小时 D 超过 1 个小时

7. 你喜欢和爸爸妈妈一起玩电脑游戏吗？
A 非常喜欢　B 喜欢 C 一般 D 不喜欢 E 很不喜欢

8. 你喜欢和朋友一起玩电脑游戏吗？
A 非常喜欢　B 喜欢 C 一般 D 不喜欢 E 很不喜欢

9. 你喜欢一个人玩电脑游戏吗？
A 非常喜欢　B 喜欢 C 一般 D 不喜欢 E 很不喜欢

10. 你有兄弟姐妹吗？
A 有  B 没有

11. 如果你有兄弟姐妹，你喜欢和他们一起玩电脑游戏吗？
A 非常喜欢  B 喜欢 C 一般 D 不喜欢 E 很不喜欢

12. 你一般什么时候想玩电脑游戏？
A 不想做作业的时候 B 因为朋友来家里想一起玩游戏 C 无聊没事的时候
D 尽可能多玩

13. 你更喜欢喝男孩还是女孩一起玩电脑游戏？
A 男孩  B 女孩

14. 你为什么喜欢玩电脑游戏？ （可多选）
A 因为可以娱乐  B 因为我想打败我的朋友 C 因为可以让我很兴奋
D 因为我可以边玩边学 E 因为我想得更高的积分

15. 你喜欢玩什么类型的游戏？（可多选）
A 冒险类  B 模拟经营类 C 动作类 D 战略类 E 角色扮演类 F 体育类
G 格斗类  H 智力类

16. 你的父母赞同你玩游戏吗？
A 非常赞同  B 赞同 C 一般 D 不赞同 E 很不赞同

17. 你听说过专门的教育游戏软件吗？ （比如《拯救灰姑娘》、《幻境游学》 ）
A 有  B 没有

18. 你有玩过专门的教育游戏吗？
A 有，请列举一下游戏的名字：__________________
B 没有

19. 你觉得玩游戏对你学习有帮助吗？
A 有，请列举一下游戏的名字：__________________
B 没有

20. 你有自己的手机吗？
A 有，请写出手机牌子和型号：__________________
B 没有

21. 你什么时候拥有自己的手机？
A 今年  B 去年 C 两年前 D 三年前 E 不知道

22. 你玩过手机游戏吗？

A 有

22a. 你喜欢玩手机游戏吗？

A 非常喜欢 B 喜欢 C 一般 D 不喜欢 E 很不喜欢

22b. 你自己下载过手机游戏吗？

A 有，请列举一下游戏的名字：__________________

B 没有

B 没有

23. 请你想象并描述一下你最想玩得游戏是什么样的？

非常感谢你的帮助！

# APPENDIX D: QUESTIONNAIRE THREE: CHILDREN'S ATTITUDES TOWARDS ELECTRONIC GAMES IN CHINESE SAMPLE (ENGLISH EDITION)

We are trying to find out primary school children's attitudes towards electronic games, and their opinions on educational game and mobile game. Although we ask for some of your information we will keep your answers safe and will not let anyone know that they were your thoughts. Please fill the questionnaire honestly. Thank you very much!

| | |
|---|---|
| School: | |
| Gender: | |
| Class: | |
| Age: | |

Please tick the correct answer by " √ "

1. Have you played electronic games before?

A. Yes B. No

2. Do you like playing electronic games?

A. like a lot B. like C. neither like nor dislike D. dislike E. dislike a lot

3. How often do you play electronic games?

A. every day B. at least once a week C. once or twice a month

4. Where do you play electronic games normally?

A. at home B. at school C. at internet cafe

5. When do you play electronic games at home?

A. mostly on weekends B. mostly on weekdays C. all the time

6. How long do you normally play in a day?

A. under 30 mins B. 30 mins to one hour C. one to two hours D. over two hours

7. Do you like playing electronic games with parents?

A. like a lot B. like C. neither like nor dislike D. dislike E. dislike a lot

8. Do you like playing electronic games with friends?

A. like a lot B. like C. neither like nor dislike D. dislike E. dislike a lot

9. Do you like playing electronic games alone?

A. like a lot B. like C. neither like nor dislike D. dislike E. dislike a lot

10. Do you have brother or sister?

A. Yes B. No

11. Do you like playing electronic games with brother or sister?

A. like a lot B. like C. neither like nor dislike D. dislike E. dislike a lot

12. When do you tend to play electronic games?

A. I play electronic games when I don't want to do my homework.

B. Friends come to my home and I play electronic games with them.

C. I play electronic games when I am bored.

D. I play electronic games as often as possible.

13. Do you prefer playing electronic games with boys or girls?

A. Boys B. Girls

14. Why do you like playing electronic games? (you can choose more than one answer)

A. Because they are fun B. Because I'd like to defeat my friends

C. Because they are exciting D. Because I learn from them

E. Because I'd like to get a high score

15. What kinds of games do you like playing?

A. Adventure games B. Simulation games C. Action games D. Strategy games

E. Role-playing games F. Sports games G. Fighting games H. Puzzle games

16. Do your parents agree you to play electronic games?

A. Strongly agree B. Agree C. Neither agree nor disagree D. Disagree

E. Strongly disagree

17. Have you heard educational games before? (such as 'Save Cinderella' and 'Study in a fairyland')

A. Yes B. No

18. Have you played educational games before?

A. Yes, please list the game name which you have played before_______________

B. No

19. Do you think the electronic games help you learning?

A. Yes, please list the game name which help you learning_______________

B. No

20. Do you have your own mobile phone?

A. Yes, please list the brand and model of your own mobile phone _______________

B. No

21. When do you own your mobile phone?

A. This year B. Last year C. Two years ago D. Three years ago E. I don't know

22. Do you have your own mobile phone?

A. Yes,

  22a. Do you like plying mobile phone games?

  A. like a lot B. like C. neither like nor dislike D. dislike E. dislike a lot

  22b. Have you downloaded game content for your mobile phone?

  A. Yes, please list the mobile phone games name which you have download_______________

  B. No

B. No

23. Please describe your favourite game

Thank you very much for your help!

## APPENDIX II: RESEARCH MATERIALS IN STUDY TWO

This appendix includes the following sections:

Appendix E: Mathematics performance test

Pre-test

1st post-test

2nd post-test

Samples of children's performance test

Pre-test

1st post-test

2nd post-test

Appendix F: Mathematics attitude questionnaire

Appendix G: Questionnaire about children's attitude towards playing mobile phone game 'brain challenge'

Appendix H: Children's interview

Appendix I: Teacher's interview

Appendix J: Consent form for parents

## APPENDIX E: MATHEMATICS PERFORMANCE TEST

Pre-test

**Mental Maths Challenge**

Time:

Name: ______ Age: ______ boy/girl

| | | |
|---|---|---|
| 3+7= | 9-2= | 12+6= |
| 12-8= | 2×7= | 1×5= |
| 18÷2= | 21÷3= | 20-10= |
| 4+13= | 45÷5= | 3×9= |
| 35÷5= | 6×3= | 40+9= |
| 21-8= | 8×6= | 17+4= |
| 18÷3= | 18-5= | 8+20= |

Page 1

page 2

| | | | |
|---|---|---|---|
| 39+8= | 7+49= | 39-6= | 36-8= |
| 9+25= | 9×5= | 42-6= | |
| 7×6= | 57+4= | 30÷6= | 70-5= |
| 76+5= | 48÷6= | 8+64= | 8×8= |
| 36÷6= | 6×10= | 42÷7= | 10×8= |
| 5+9+6= | 90÷10= | 72-5= | 12×2= |
| 2+6+8= | 42×10= | 129-4= | 56÷8= |
| 94-50= | 16+5+3= | 63-40= | 72÷9= |
| 20+10+15= | 8× ☐ =6×4 | 4×3=20- ☐ | 54-11= |
| 87+13= | 83-59= | 63+29= | 80-21= |

1st post-test

# Mental Maths Challenge

Time:

Name: ______ Age: ______ boy/girl

page1

3+7= | 9-2= | 12+6= | 12-8=

2×7= | 1×5= | 18÷2=

21÷3= | 20-10= | 4+13= | 45÷5=

3×9= | 35÷5= | 6×3=

40+9= | 21-8= | 8×6= | 17+4=

18÷3= | 18-5= | 8+20=

39+8= | 39-6= | 7+49= | 36-8=

Page2

9+25= | 9×5= | 42-6=

7×6= | 57+4= | 30÷6= | 70-5=

76+5= | 48÷6= | 8+64=

8×8= | 36÷6= | 6×10= | 42÷7=

10×8= | 5+9+6= | 90÷10=

72-5= | 12×2= | 2+6+8= | 129-4=

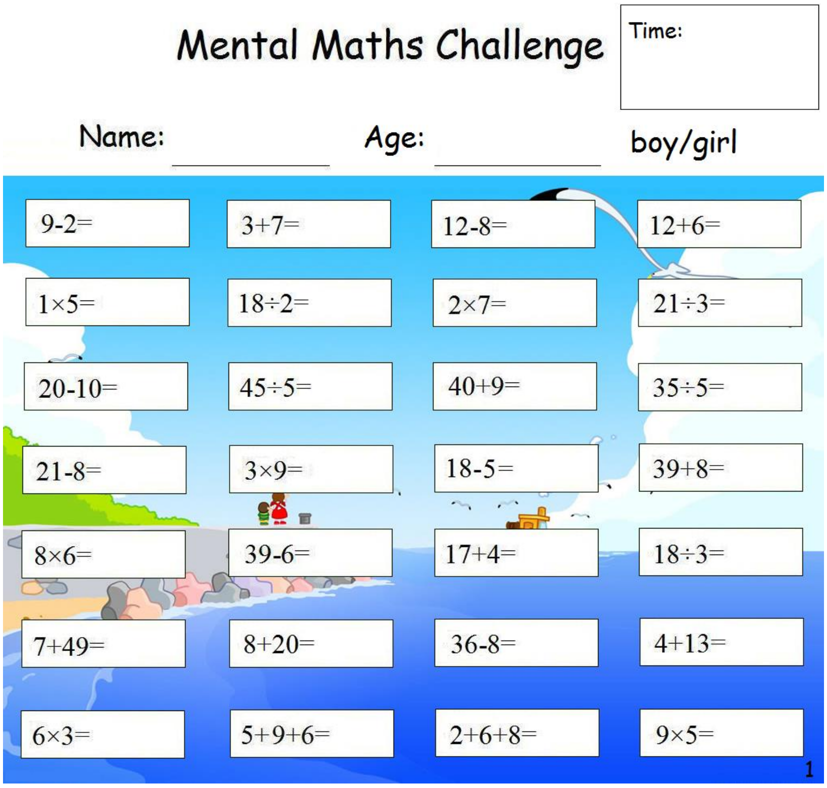
42×10= | 56÷8= | 94-50=

16+5+3= | 63-40= | 72÷9= | 63+29=

4×3=20- $\boxed{\phantom{0}}$ | 54-11= | 8× $\boxed{\phantom{0}}$ =6×4

87+13= | 20+10+15= | 83-59= | 80-21=

2nd post-test



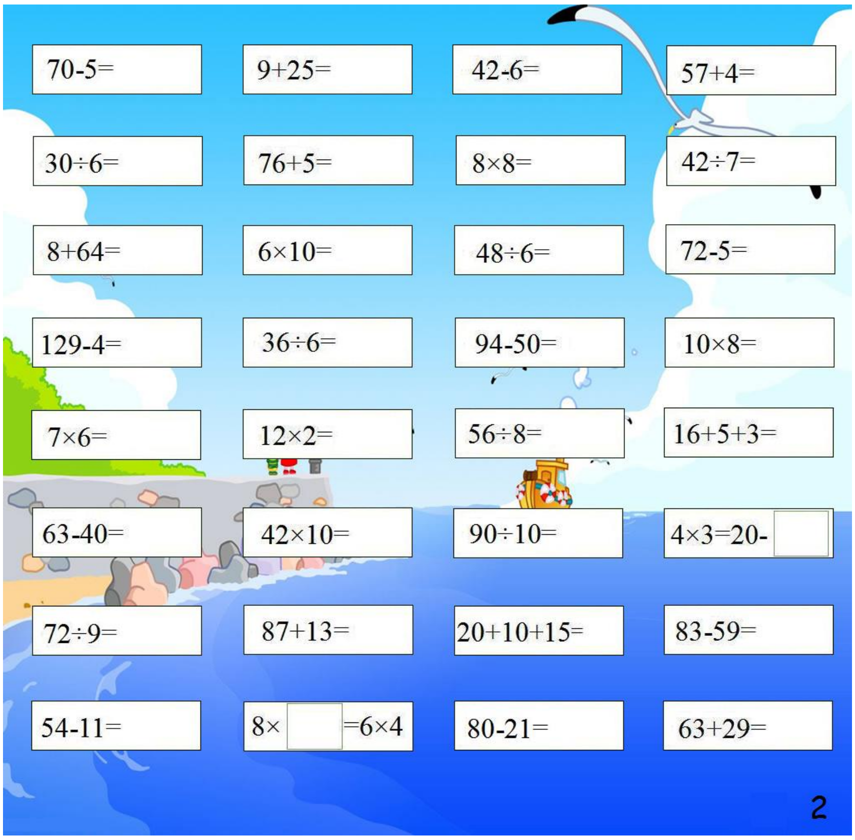
Mental Maths Challenge

Time:

Name: ____ Age: ____ boy/girl

| | | | |
|---|---|---|---|
| 9-2= | 3+7= | 12-8= | 12+6= |
| 1×5= | 18÷2= | 2×7= | 21÷3= |
| 20-10= | 45÷5= | 40+9= | 35÷5= |
| 21-8= | 3×9= | 18-5= | 39+8= |
| 8×6= | 39-6= | 17+4= | 18÷3= |
| 7+49= | 8+20= | 36-8= | 4+13= |
| 6×3= | 5+9+6= | 2+6+8= | 9×5= |

1

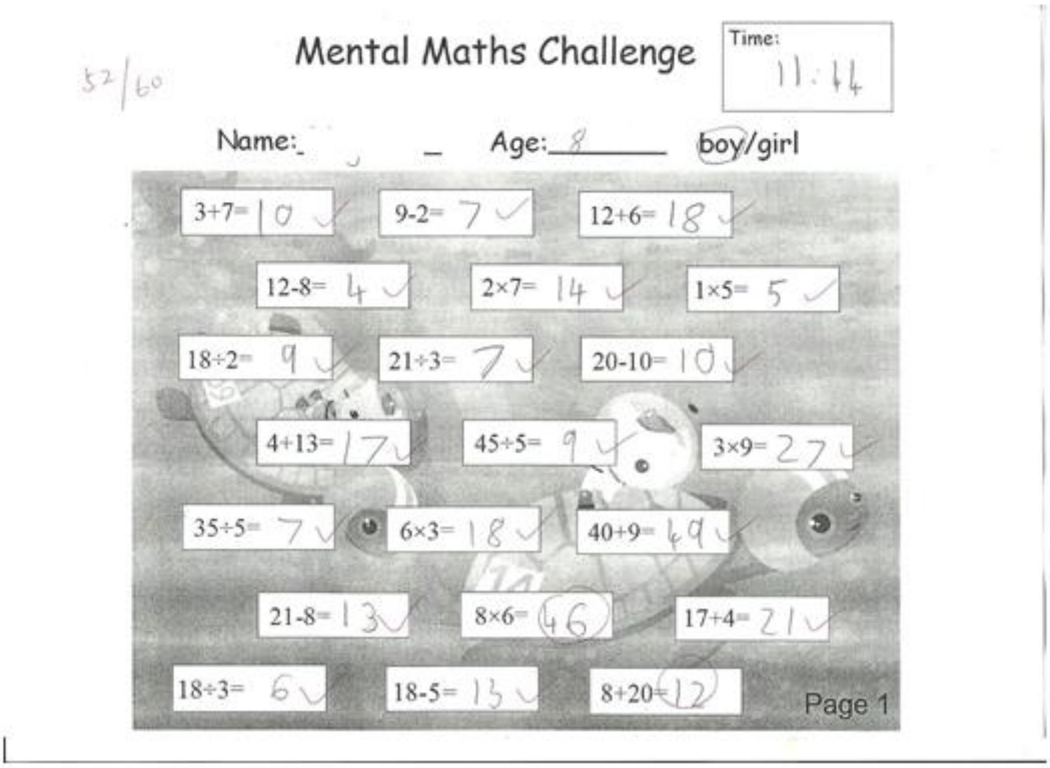


| | | | |
|---|---|---|---|
| 70-5= | 9+25= | 42-6= | 57+4= |
| 30÷6= | 76+5= | 8×8= | 42÷7= |
| 8+64= | 6×10= | 48÷6= | 72-5= |
| 129-4= | 36÷6= | 94-50= | 10×8= |
| 7×6= | 12×2= | 56÷8= | 16+5+3= |
| 63-40= | 42×10= | 90÷10= | 4×3=20- |
| 72÷9= | 87+13= | 20+10+15= | 83-59= |
| 54-11= | 8× =6×4 | 80-21= | 63+29= |

2

SAMPLES OF CHILDREN’S PERFORMANCE TEST

Pre-test



52/60

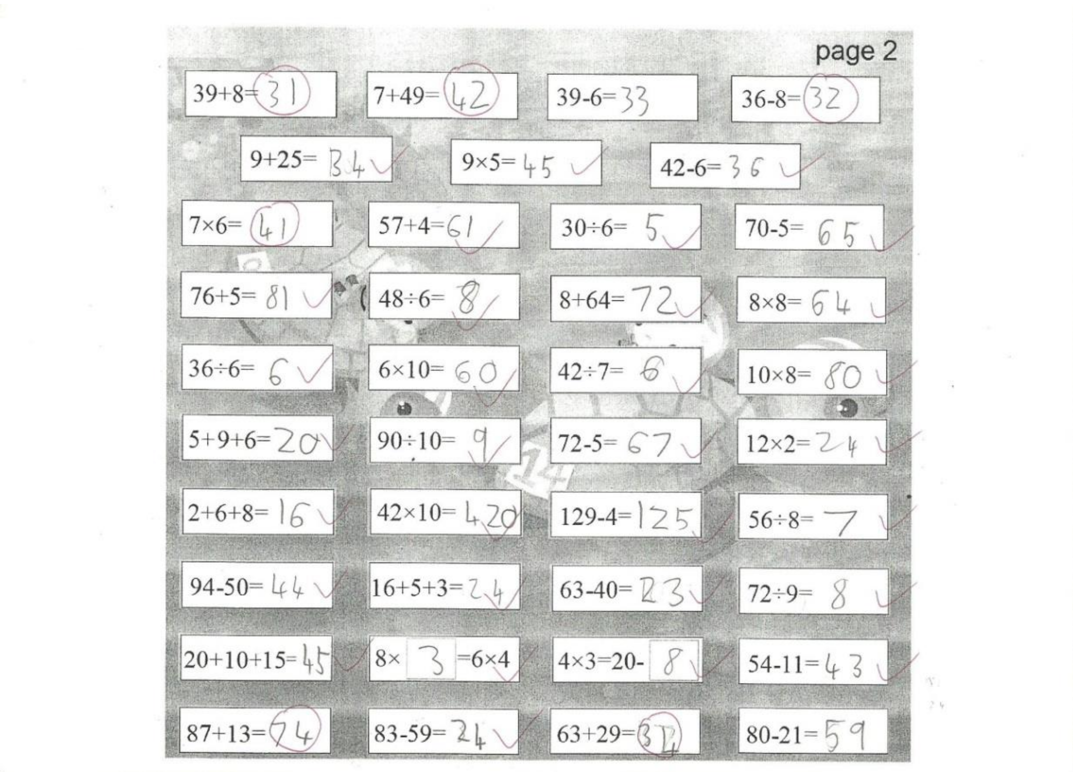
Mental Maths Challenge

Time: 11:44

Name: Age: 8 boy/girl

| | | |
|---|---|---|
| 3+7= 10 | 9-2= 7 | 12+6= 18 |
| 12-8= 4 | 2×7= 14 | 1×5= 5 |
| 18÷2= 9 | 21÷3= 7 | 20-10= 10 |
| 4+13= 17 | 45÷5= 9 | 3×9= 27 |
| 35÷5= 7 | 6×3= 18 | 40+9= 49 |
| 21-8= 13 | 8×6= 46 | 17+4= 21 |
| 18÷3= 6 | 18-5= 13 | 8+20= 12 |

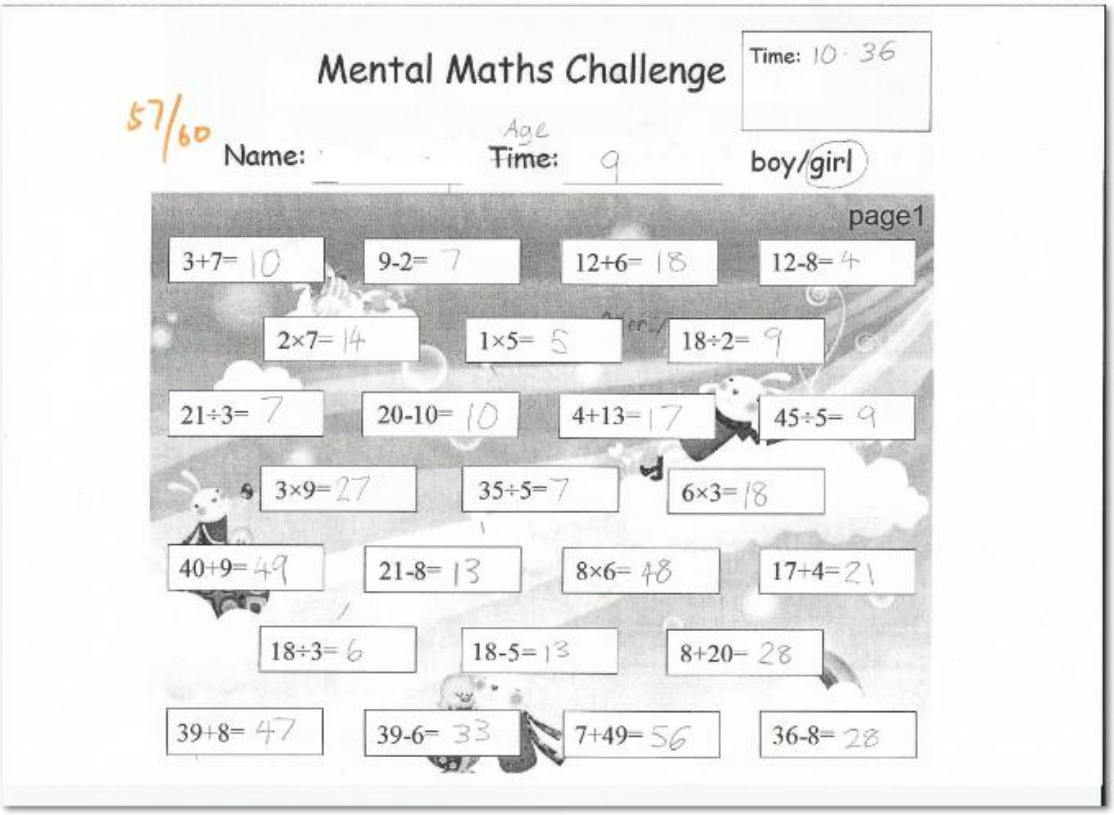
Page 1



page 2

| | | | |
|---|---|---|---|
| 39+8= 31 | 7+49= 42 | 39-6= 33 | 36-8= 32 |
| 9+25= 34 | 9×5= 45 | 42-6= 36 | |
| 7×6= 41 | 57+4= 61 | 30÷6= 5 | 70-5= 65 |
| 76+5= 81 | 48÷6= 8 | 8+64= 72 | 8×8= 64 |
| 36÷6= 6 | 6×10= 60 | 42÷7= 6 | 10×8= 80 |
| 5+9+6= 20 | 90÷10= 9 | 72-5= 67 | 12×2= 24 |
| 2+6+8= 16 | 42×10= 420 | 129-4= 125 | 56÷8= 7 |
| 94-50= 44 | 16+5+3= 24 | 63-40= 23 | 72÷9= 8 |
| 20+10+15= 45 | 8× 3 =6×4 | 4×3=20- 8 | 54-11= 43 |
| 87+13= 74 | 83-59= 24 | 63+29= 32 | 80-21= 59 |

1st post-test



Mental Maths Challenge

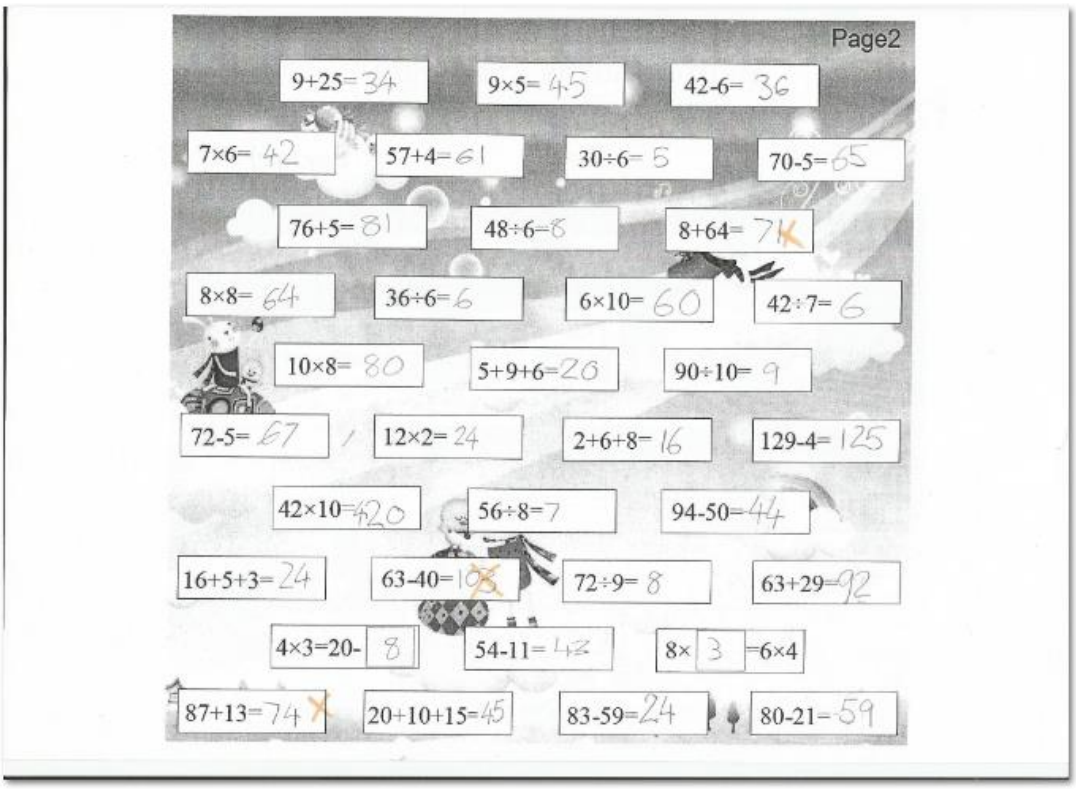
Time: 10 · 36

57/60

Name: Age Time: 9 boy/girl

page1

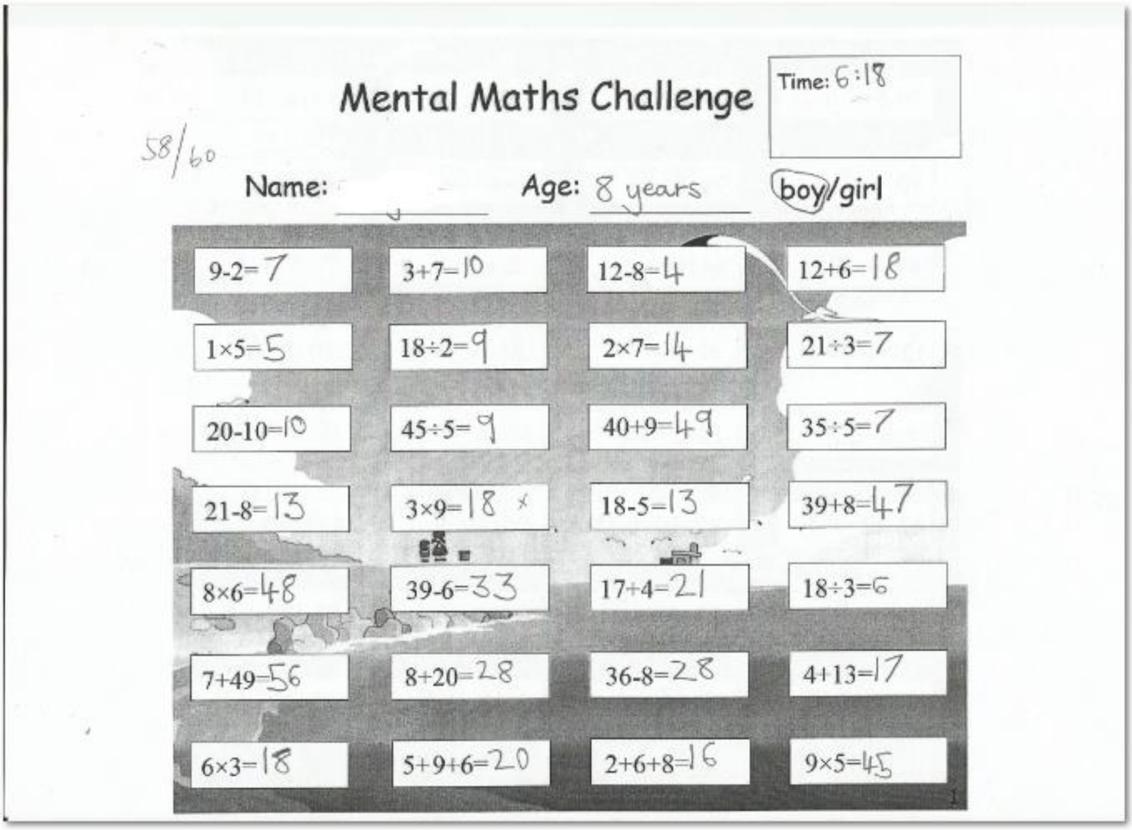
| | | | |
|---|---|---|---|
| 3+7= 10 | 9-2= 7 | 12+6= 18 | 12-8= 4 |
| 2×7= 14 | 1×5= 5 | 18÷2= 9 | |
| 21÷3= 7 | 20-10= 10 | 4+13= 17 | 45÷5= 9 |
| 3×9= 27 | 35÷5= 7 | 6×3= 18 | |
| 40+9= 49 | 21-8= 13 | 8×6= 48 | 17+4= 21 |
| 18÷3= 6 | 18-5= 13 | 8+20= 28 | |
| 39+8= 47 | 39-6= 33 | 7+49= 56 | 36-8= 28 |



Page2

| | | | |
|---|---|---|---|
| 9+25= 34 | 9×5= 45 | 42-6= 36 | |
| 7×6= 42 | 57+4= 61 | 30÷6= 5 | 70-5= 65 |
| 76+5= 81 | 48÷6= 8 | 8+64= 71 X | |
| 8×8= 64 | 36÷6= 6 | 6×10= 60 | 42÷7= 6 |
| 10×8= 80 | 5+9+6= 20 | 90÷10= 9 | |
| 72-5= 67 | 12×2= 24 | 2+6+8= 16 | 129-4= 125 |
| 42×10= 420 | 56÷8= 7 | 94-50= 44 | |
| 16+5+3= 24 | 63-40= 10 X | 72÷9= 8 | 63+29= 92 |
| 4×3=20- 8 | 54-11= 43 | 8× 3 =6×4 | |
| 87+13= 74 X | 20+10+15= 45 | 83-59= 24 | 80-21= 59 |

2nd post-test



## Mental Maths Challenge

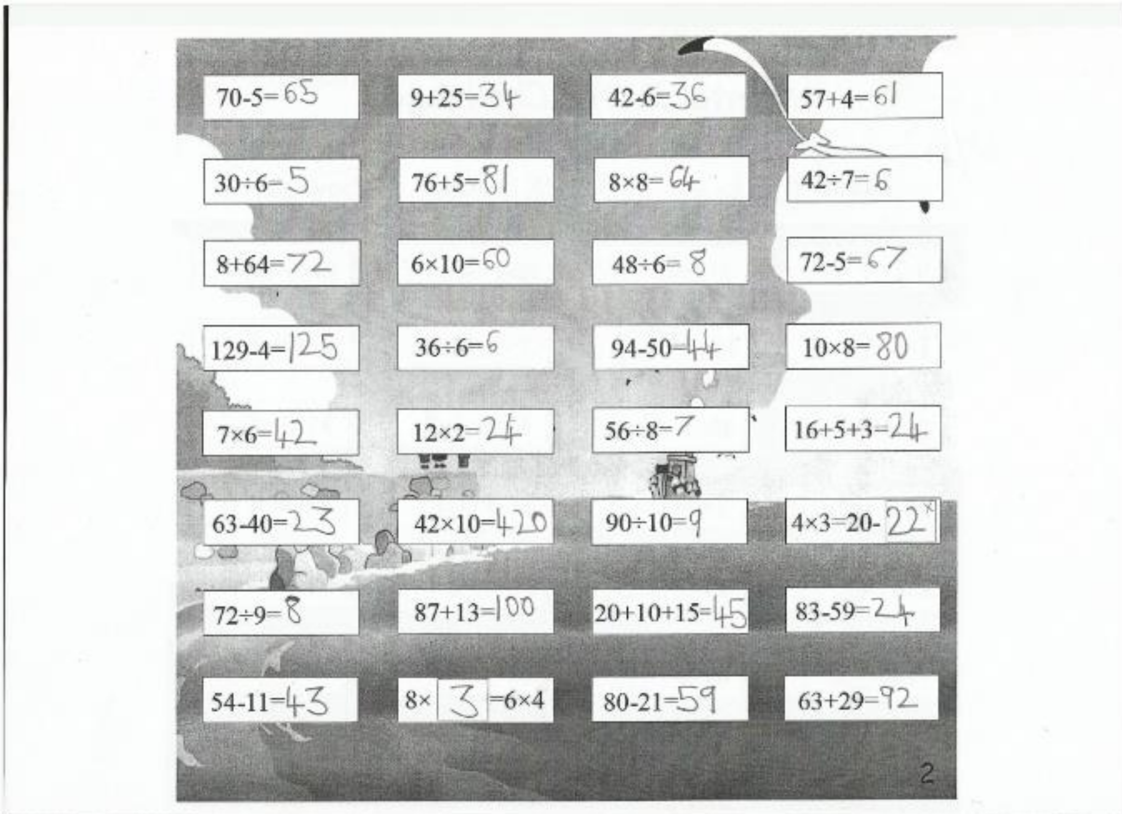
Time: 6:18

58/60

Name: Age: 8 years boy/girl

| | | | |
|---|---|---|---|
| 9-2=7 | 3+7=10 | 12-8=4 | 12+6=18 |
| 1×5=5 | 18÷2=9 | 2×7=14 | 21÷3=7 |
| 20-10=10 | 45÷5=9 | 40+9=49 | 35÷5=7 |
| 21-8=13 | 3×9=18 × | 18-5=13 | 39+8=47 |
| 8×6=48 | 39-6=33 | 17+4=21 | 18÷3=6 |
| 7+49=56 | 8+20=28 | 36-8=28 | 4+13=17 |
| 6×3=18 | 5+9+6=20 | 2+6+8=16 | 9×5=45 |

1



| | | | |
|---|---|---|---|
| 70-5=65 | 9+25=34 | 42-6=36 | 57+4=61 |
| 30÷6=5 | 76+5=81 | 8×8=64 | 42÷7=6 |
| 8+64=72 | 6×10=60 | 48÷6=8 | 72-5=67 |
| 129-4=125 | 36÷6=6 | 94-50=44 | 10×8=80 |
| 7×6=42 | 12×2=24 | 56÷8=7 | 16+5+3=24 |
| 63-40=23 | 42×10=420 | 90÷10=9 | 4×3=20-22 × |
| 72÷9=8 | 87+13=100 | 20+10+15=45 | 83-59=24 |
| 54-11=43 | 8×3=6×4 | 80-21=59 | 63+29=92 |

2

# APPENDIX F: MATHEMATICS ATTITUDE QUESTIONNAIRE

| Mathematics Attitude Scale | | | | | |
|---|---|---|---|---|---|
| For each statement, mark the scores in the boxes to show how much you agree or disagree | Strongly Disagree | Disagree | Neither Disagree Nor Agree | Agree | Strongly Agree |
| | 1 | 2 | 3 | 4 | 5 |
| *Example:* I like chocolate | | | | | |
| 1 Maths is a very worthwhile and necessary. | | | | | |
| 2 I look forward to doing maths. | | | | | |
| 3 I like to solve new problems in maths. | | | | | |
| 4 Maths is hard for me. | | | | | |
| 5 My parents are interested in my maths work. | | | | | |
| 6 What I learn in maths is very important to me. | | | | | |
| 7 I am happier doing maths than other subjects. | | | | | |
| 8 I would like to stop doing maths in school. | | | | | |
| 9 I study maths because I know how useful it is. | | | | | |
| 10 I am sure of myself when I do maths. | | | | | |
| 11 My teachers have made me feel I can do well in maths. | | | | | |
| 12 I can get good marks in maths. | | | | | |
| 13 Maths is dull and boring. | | | | | |
| 14 I like playing maths games. | | | | | |
| 15 My parents encourage me to work hard at maths. | | | | | |
| 16 Doing maths is a waste of time. | | | | | |
| 17 I like the challenge of maths. | | | | | |
| 18 Playing maths games help me make progress in maths. | | | | | |
| 19 Doing maths makes me feel nervous. | | | | | |
| 20 Maths has been my worst subject. | | | | | |
| 21 I believe studying maths helps me with problem solving in other areas. | | | | | |
| 22 I am sure I could do more difficult work in maths. | | | | | |
| 23 I have usually enjoyed studying maths in school. | | | | | |
| 24 Most subjects I can do OK, but I just cannot do a good job with maths. | | | | | |
| 25 Maths is not important. | | | | | |
| 26 My teachers think I could do well in maths. | | | | | |

APPENDIX G: QUESTIONNAIRE ABOUT CHILDREN'S ATTITUDE TOWARDS PLAYING MOBILE PHONE GAME 'BRAIN CHALLENGE'

| Game Attitude Scale | | | | | |
|---|---|---|---|---|---|
| For each statement, mark the scores in the boxes to show how much you agree or disagree | Strongly Disagree ☹ | Disagree | Neither Disagree Nor Agree | Agree | Strongly Agree ☺ |
| | 1 | 2 | 3 | 4 | 5 |
| 1 I like playing mobile game "Brain Challenge". | | | | | |
| 2 Playing mobile game "Brain Challenge" help me make progress in maths. | | | | | |

APPENDIX H: CHILDREN'S INTERVIEW

The setting for the interviews was in a meeting room. Seven children (5 boys and 2 girls) were sitting by a round table with the researcher and her supervisor. The interview was conducted in the afternoon on 19th June 2009. The interview was in informal and friendly atmosphere where the students were informed that all the information in the interview would be confidential. Permission had been given for voice recording of the interview.

In order to find out children's views on playing mobile phone game 'Brain challenge', some pre-set questions were prepared before interview and listed below.

- Have you played mobile phone games before?
- Did you like the mobile phone game 'brain challenge'?
- You have played two mobile games: Trout Route and Arithmetic. Which one do you like more? Why do you like this game?
- What are the good things about playing mobile games?
- What are the not-so-good things about playing mobile games?
- Compared with your normal mathematics work, which one is better?
- Do you think the mobile games have made you better in sums and why?
- When you played the mobile game, did you try to get a higher score or try to beat your friends' scores?
- Do you like playing other games at home?
- Do your parents like you playing games?

Extracts of Children's interview transcript

Note: When the recording was replayed, the quality of the sound was variable. In some sections, children's responses were indistinct. This was most noticeable when trying to decide which child said which comment. Therefore, in the following interview transcript, the label Child A does not relate to one specific child throughout. The capital letter 'A' or 'B' only used to distinguish what each child said. If there was no other child answered the question, 'Child' was used with no following capital letter. Also, any sections which are indistinct are marked in square brackets.

Researcher: Do you like playing the game 'brain challenge'?

All children: Yes.

Researcher: Do you feel bored at times playing the same game?

All children: No.

Researcher: Do you think playing mobile game has made you better in sums?

All children: (nodded heads) Yes.

Researcher: Why do you think it's make you better in sums?

Child A: because there are hard sums in some of them.

Child B: [there are] hard sums you have be thinking about and even more.

Child C: They make you work faster as well

Child D: Cos you're timed.

Child E: Next time you might be seen one (unclear).

Researcher: OK. What you said there, it's interesting. You said, it makes you work faster. Do you think make you *think* faster?

Child: Yes. (some nodding heads)

Researcher: So, when you play the game you think faster. but later on, doing your maths, what kind of maths did you do?

Child: TeeJay reinforcement.

Researcher: TeeJay Maths, is it?

Researcher: OK - when you're doing that with your pencil and your jotter, do you still think quickly?

(Some uncertainty: some children replied 'Yes' and one child responded by 'Erm')

Researcher: Most of you said 'Yes', it's good. What I am wondering is when you doing maths in your jotter, you have to look what's written, you've got to think about it, get your pencil and write something down. When you play the game, it's different, isn't it? I'm just wondering if it's harder on the game because you're always having one answer and quickly have to get another one and quickly another one. I'm just wondering if it is a bit harder when you're playing on the mobile game? What do you think?

Children: Easier (general agreement)

Researcher: You think it's easier? Why do you think it's easier?

Child: Because you don't need to write anything down.

Researcher: anybody else think that?

No further response from children.

Researcher: OK. It's another question…If I said to you, what's the best thing about the mobile game? Why do you like it? Just one thing. What would you say?

Child A: you have to think quick.
Child B: because you get to do more levels and harder ones

Researcher: Sometimes when we do sums in like TeeJay Maths, sometimes we are not sure so we count on our fingers to help us. Do you do that sometimes with the mobile or do you just do all in your heads on the mobile.

Several children replied 'in your head' together.

Researcher: Most of you said you do it in your head. Anybody say sometimes you still count your fingers as well?

(one girl demonstrated she will do it with her fingers but she did not say)

Researcher: Ok, that's your answer then? (Laughs…)

Do you find any not-so-good things about playing?

Children: (all) No.

Researcher: Do you like *everything* about it?

All children replied: Yes.

Researcher: Here is a question. If you are the person who invented this game, could you say any way to make better?

children: No (shaking heads).

Researcher: Do you want to be the first one to finish the game, or to beat your highest score?

All children: Higher score (general agreement)

Researcher: Do you like doing maths in your jotter with TeeJay maths or do you prefer to do it with mobile games?

(a show of hands tells us that 4 children like TeeJay maths and 3 like mobile games )

Researcher: Why do you say TeeJay is better?

Child A: it's easier when you do TeeJay because you can count on your fingers.

Child B: you are not against the clock.

Researcher: Why do you say mobile is better?

Child C: Playing is fun and you can get a higher score and […indistinct comment…].

Child D: it was easy to get thinking, […] no worksheets.

Researcher: When you play a mobile game and you get your score, are you trying to beat your *own* best score or try to beat *your friends'* score?

(Some children replied 'both' and some children replied 'your own score'.)

Researcher: How many of you are mainly doing it to beat your own score - and if you can do better than last time?

(most hands go up)

Researcher: OK. Almost everybody.

How many of you try to beat your friends' score?
You were being competitive; you can be better than the others.

(one child only agrees with this)

Child: I try to do 'both'.

Researcher: Which game do you like best, because there are two games?

(5 children like Trout Route and 2 like Arithmetic after vote)

Researcher:  Why do you like Trout Route best?

(child does not offer an answer)

Researcher: You are not sure – you just like it, yes?

(Child nods)

Researcher:  How about you?

Child A: […indistinct comment…]. You just need to think of the answer in your heads and then just go on.

Researcher: why do you say Trout Route is better?

Child B: Because sometimes you add like fifty add [unclear], something like that. It's hard thinking […unclear…].

Child C: because you're adding and taking away on it and adding other numbers, up to a hundred in that.

Child D: because in Arithmetic, you only have to move the side arrows. The Arrows on Trout Route you can move up, sideways and down.

Researcher: Is Trout Route a bit difficult, or does it give you more things to do?

Children replied together: more things to do

Researcher: is that better than the Arithmetic one?

Children:  (nodded heads) Yes.

Researcher: Had any of you played mobile games before?

(Five of children replayed 'Yes'. Two children said 'No')

Child A: I've got my own mobile phone.

Child B: My gran gave all the grandchildren a phone.

Child C: So do I.

Child D: I got one when you have to join, like a music things to give a good score. Another one you try to get the top of tower, click click crystals.

Researcher: What kinds of things do you normally like doing at home?

The following suggestions were offered by the children.
Child A: I […] played my Xbox.
Child B: I often played Xbox.
Child C: I […] in my Nintendo.
Child D: I am watching TV.
Child D: I read book.
Child E: I used to played with my friends, usually stay inside, doing my homework, […unclear…], sometimes playing with Nintendo, sometimes playing with my phone.

Researcher: If you said what the things you like doing best in your free time, you know, let's just say I like playing football in my most free time, that would be my top of my list, I like watching TV second top, how about playing mobile game or games like Nintendo whatever, how many would you say playing games is your very favourite thing?

(4 children said playing games was their very favourite thing)

Researcher: How many would you say it's one of your favourite things but not your really favourite?

Some of children (nodded heads).

Researcher: Lot of you seem to like say that's one of your favourite things is electronic games.

Do your parents like you playing these games?

(Some children responded 'Yes' and some children said 'No'.)

Two children responded with more ideas:

Child A: Not all the time.

Child B: My mum said get outside since you will be a couch potato.

Researcher: Probably mum and dad say 'ok, for a while not all the time.' Is that idea?

Children: Yes.

## APPENDIX I: TEACHER'S INTERVIEW

The setting for the interviews was in a classroom. Teacher was sitting beside the researcher and her supervisor. The interview was conducted on 19th June 2009. The teacher was reminded that the interview would be taped by voice recorder to help remember what she said, all the information from the interview would be held securely and only for this particular study.

In order to find out more details about the children's mobile game playing and the teacher's views on using games in the classroom, some questions were prepared before the interview:

- Tell me about your attitudes towards using mobile phone games in the classroom - before this project, and after.
- In your view, what are the benefits and disadvantages of mobile phone games?
- What do you think of the game 'brain challenge'?
- Do you feel children are more confident with mathematics as a result of this work?
- Will you use mobile phone games in the future?

Extracts of Teacher's interview transcript

Note: When the recording was replayed, the quality of the sound was variable. I will miss out some sections if they were not clear or they were not relevant to this study.

Researcher: Could you please tell me your attitude to mobile games before running the project?

Teacher: I was keen to take the project on board because I have already used Nintendo in the classroom, so I wanted to see whether there was going to be any improvement with the mobile phone, as I found with Nintendo's. So I was keen to carry out this project.

Researcher: Now after 6 weeks of the project running, what's your attitude now?

Teacher: I like the mobile phones, I like the games. I don't like them quite as well as Nintendo games because it takes longer to set them up and sometimes text messages come through and sometimes the phone rings. But the children have liked them. From an organisation point of view, the fact was taking two groups for 15mins. It will be a big chunk of your time, having half an hour used up. Between the two groups, you just make sure they all have equal time. It would be better – and the ideal situation would be all the children have their own phone and they could be done together. Purely just for this research, if it was within your own classroom organisation, you would organise it a different way, slot it into your routine, but for this study it was just, erm, because it was two groups for 15 mins, it takes a quite chunk of time.

Researcher: So if everyone has a mobile, it will be easier to manage**?**

Teacher: It will be easier for this particular study. But once you were using them within your classroom situation, you will develop your own organisation, your own routine, it will slot better probably. So that respect, that would be good then.

Researcher: Do you think that you need to have a specific time for children to play games, like morning or afternoon. Which is better?

Teacher: I prefer, we always do maths in the morning just before playtime. So the children did the study always first thing in the morning. Unless there is something else on like […] this is a very busy term and this is probably the worst term to do a study like this because so many other things are going on. So within 6 weeks the children have done the mobile phone various times of a day, just slotting with the busy timetable. But under normal circumstances and in a normal week, I would always do the mobile phones first thing.

Researcher: So after doing the project, in the morning time you will still do the maths.

Teacher: Yes, maths is always done normally up to playtime. So if it was normal week, I would always do the mobile phones first thing.

Researcher: What kind of things do you normally do for maths?

Teacher: On a normal day, we start with whole class mental, with do quick fire mental with the teacher, then we'll go to the own groups and some use the computer to do program, 'Education city' is one resource we used, another group will be on Nintendo's and then just make sure have a chance to do all these things within an hour and half till to play time.

Researcher: Will you continue to run the mobile game to the end of term, or change back to normal?

Teacher: I think you can definitely incorporate mobile phones into your day because you have something different to gain. And you don't have to do the computer, the Nintendo's, the mobile phone, you know, every day. I will, probably, if we have the mobile phones in the classroom all the time, I will again set up a different organisation and different timetable: get mobile phones on certain days, maybe Nintendo on other days, so it's ideal for the children. We will work like that.

Researcher: Do you think it is easy to manage the mobiles for the pupils?

Teacher: Yes, the mobile phones are fine and you make sure they were charged up – apart from today. That one, today was the last day, so that was it. Yeah, it was easy and children have enjoyed using them and they were slotted into the routine, definitely yes.

Researcher: Do you think there have been any changes for children's learning?

Teacher: Yes, there definitely has been improvement with the learning, with everything we've been doing. The class has always been involved in a lot of mental work on the computers, with Nintendo's, now on the mobile phones. As for the improvement mentally with this short study, it's difficult to judge because it's the last term, you know, everything […unclear…], have been […unclear…] for last 2 weeks, so maths work, regular maths work hasn't been as normal as usual, there are too many other things going on, you know. If we'd done it in another term, probably it been better.

Researcher: What do you think of the game 'brain challenge'?

Teacher: I just felt it takes a longer time to set mobile phones up to get into it. All the different buttons had to be pressed many times to get set up. That is the only bad thing about it. Once the children were into the games, they enjoyed them, enjoyed the two games they had to play. At the start, I found, trout route, particular, a little bit tricky. Once children did it for a few days, they got into […unclear…], easier then for them.

Researcher: If you hand out all the mobiles to the students, will the pupils do it by themselves?

Teacher: Yes.

Researcher: Do you think the mobile improves children's self-management?

Teacher: Yes, yes, it's very good to do that anyway because they've been used to Nintendo's in the classroom, so in that respect, we just continue to do the same thing. Probably in the class if we never had experience of using handheld games to improve maths, you'll see great improvement with self-management because I noticed that improvement when I introduced the Nintendo in the classroom. You know, that's already been done children can sit by themselves, work their way through the games but in the same way, they were able to continue those skills then with mobile phones.

Researcher: So you think maybe because they have Nintendo game experience, it's easier to manage now?

Teacher: Yes, they were more used to playing similar types of games, work by themselves, and record their own scores. They were used to doing that, but certainly they enjoyed mobile phones too.

Researcher: Do you think that 15 mins is too long for children to play?

Teacher: I felt, from a management point of view, I felt it was too long when you had to do it twice. If children had their own mobiles, they could all do it together. But it was just for this particular study. If you could organise your day, it would slot better, maybe 15 mins would be OK. We hadn't played Nintendo for as long as that. It was the longest stretch of time to play a game like that.

Researcher: What kind of things were children missing out on to do 15 mins of mobile gaming?

Teacher: They were replacing Nintendo's, because (for this study) they weren't allowed to do anything else, no computers or no Nintendo's. These two kinds of things were missed out to do the mobile study.

Researcher: Some people would argue that children improved in maths because they got 15mins practice extra. What do you think?

Teacher: I think some teachers maybe make a mistake, as they are still doing the same amount of written work, and then an extra 15 minutes. But you don't have to do the same thing, you don't have to do the test pages, you don't have to do in an order, you know, you can choose not to do the written work for that amount of time and then to do something different that day or not so much.

Researcher: What's your feeling about the children's motivation?

Teacher: I mixed everything. They liked them because 'I want to go to the mobile phones!' Not every child in the class had a mobile phone, so it was novelty; they were getting to use mobile phone, they enjoy different games, they like that. […unclear…] They like to get A. When they record (their score) they will say 'I got A, I got A'. Because they gradually did better and better, they were glad. They used to get C and then got B, that was great. Children enjoy that. They liked the games, I think they prefer 'trout route', when I looked over all the results, like some of them have done arithmetic one, but it seemed they like trout route, […unclear…] all filled in the top, not many had done the arithmetic. The game was more appealing to them. They were working by themselves, were able to do it at their own pace. […unclear…]. They could just sit there with their own phone and just go easily and pace it and nobody was around them. […unclear…] I was quite happy they were going on with their own pace and made an improvement in learning.

Researcher: Do you feel children have become more confident with the maths?

Teacher: I would say it definitely builds the confidence. Yes. When they come to do in the test, I suppose it would, yes, logically would build the confidence. […unclear…]. I would say definitely make them more confident and ready to tackle more mathematics. Like**, a boy, very quiet, but on mobile, on Nintendo, he is right up there with best of them. Even ** (boy's name) keeps up with them. With written work, test process, or anything like that, very slow, but that, he can keep up, because it was not written. He's just a slow writer, rather than a slow leaner; with his brain he can go quick, but he can't get the information from his brain to his hand to get up speed.

That's one boy as well, when we were doing with Nintendo's, although it's not the same (with mobile phone). There was a competition to find out who was first, second, third, fourth, fifth and sixth. He was keen he was first sometimes, […unclear…]. With the mobile, less children share these results, they didn't know exactly, unlike the Nintendo's, where they know their position. But they did know an improvement, obviously self-improvement with the grades.

Researcher: They can see how they develop themselves, without comparing themselves with somebody else.

Teacher: Yes.

Researcher: There were two games in the mobile, who decided what game to play?

Teacher: They decided the game they wanted to play.

Researcher: and the level of games as well?

Teacher: Yes, they decided. Some of them were quite keen to start with easy ones, some of them wanted to test themselves and move on to medium and hard. Others did not feel confident and I feel they were quite keen to stick the easy ones for a good long time until they felt, 'I am really good at that', then the confidence built up. When they were doing the medium and hard level, if they were not confident then they would set back into easy again to get that boost because they liked to achieve the A.

Children definitely have enjoyed the game and I enjoyed taking part and it opened my eyes as well. It let me see the different activities. I have never thought about mobile phones for mental maths in the classroom.

APPENDIX J: CONSENT FORM FOR PARENTS

April, 2009

Dear Parent,

I am a PhD student in the School of Education, Social Work and Community Education at Dundee University. I am undertaking research into how electronic games can be used in primary schools. I am interested in using mobile games to support children's mathematics learning. Mobile games can make children's math learning fun and there is evidence that it helps their mental calculation.  I want to learn more about how playing games may motivate them to try to do better.

I have chosen your child's class to work with in the school. The plan is for children to play mathematics games around 15 minutes every weekday morning for 6 weeks, and we will try to measure how it improves their mathematics. This will involve children completing a short number challenge and a questionnaire. All information will be confidential and no children will be named in any report.

I hope you will agree to allow your child to participate. Can you please fill in the permission slip to say if it is possible to work with your child on this study?

Please accept my sincere thanks for your co-operation.

Yours Faithfully

Ming Chen

Please delete as appropriate.

---

I do / do not give my permission for my child to participate in this study.

Signed__________________ Date___________________

## APPENDIX III: RESEARCH MATERIALS IN STUDY THREE

This appendix includes the following sections:

Appendix K: Mathematics performance test

Least ability group

Middle group

Top group

Samples of children's test sheets

Least ability group

Middle group

Top group

Appendix L: Questionnaire about children's attitude towards playing online mathematics game

Appendix M: Children's paper-pencil game worksheet

Appendix N: Observation sheet

Appendix O: Extracts of Teacher's interview transcript

Appendix P: Consent form for parents

Appendix Q: UREC approved letter

APPENDIX K: MATHEMATICS PERFORMANCE TEST

Least ability group

Mental Maths Challenge

Time:

Name:__________ Age:________ boy/girl

| | | | |
|---|---|---|---|
| 3+7= | 3+5= | 12+6= | |
| 2+3= | 3+6= | 4+9= | |
| 5+8= | 5+9= | 7+7= | |
| 4+13= | 8+8= | 6+7= | |
| 3+14= | 6+21= | 40+9= | |
| 3+14= | 2+18= | 17+4= | |
| 15+4= | 5+18= | 8+20= | Page 1 |

page 2

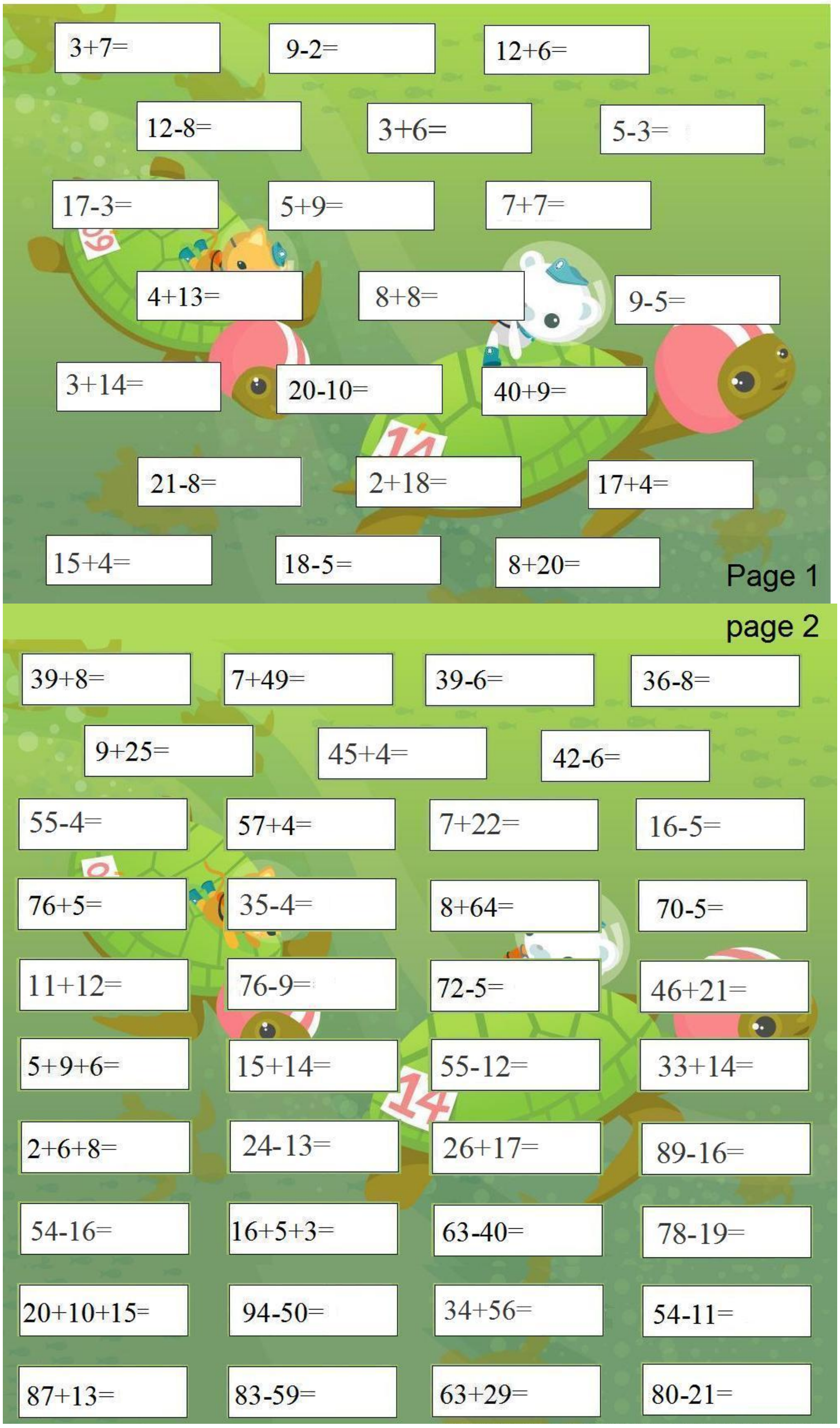
| | | | |
|---|---|---|---|
| 39+8= | 7+49= | 22+3= | 4+39= |
| 9+25= | 45+4= | 6+17= | |
| 3+54= | 57+4= | 7+22= | 6+28= |
| 76+5= | 43+5= | 8+64= | 54+6= |
| 11+12= | 36+20= | 12+15= | 46+21= |
| 5+9+6= | 15+14= | 55+12= | 33+14= |
| 2+6+8= | 25+32= | 26+17= | 27+19= |
| 12+36= | 16+5+3= | 32+18= | 49+15= |
| 20+10+15= | 54+26= | 34+56= | 89+16= |
| 87+13= | 78+19= | 63+29= | 36+18= |

Middle group

# Mental Maths Challenge

Time:

Name:__________ Age:________ boy/girl



Top group

# Mental Maths Challenge

Time:

Name:__________ Age:________ boy/girl

| | | | |
|---|---|---|---|
| 2÷2= | 4÷4= | 6÷2= | |
| 9÷3= | 4÷2= | 6÷3= | |
| 12÷2= | 21÷3= | 15÷5= | |
| 16÷4= | 45÷5= | 12÷1= | |
| 35÷5= | 24÷3= | 18÷3= | |
| 20÷10= | 16÷2= | 18÷2= | |
| 15÷1= | 12÷4= | 20÷5= | |

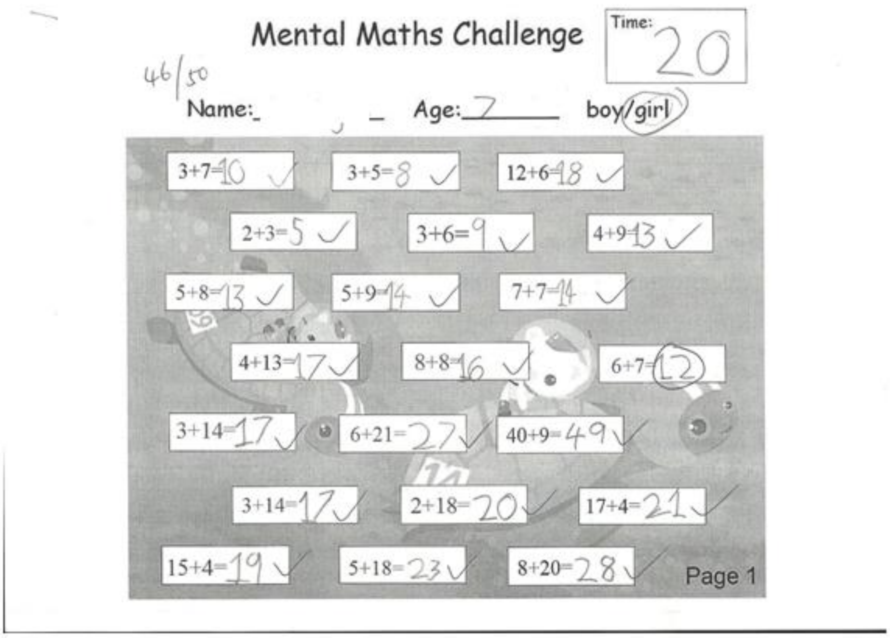
Page 1

page 2

| | | | |
|---|---|---|---|
| 30÷5= | 28÷4= | 50÷10= | 24÷4= |
| 30÷3= | 30÷10= | 28÷2= | |
| 20÷2= | 42÷3= | 40÷4= | 70÷10= |
| 36÷2= | 40÷10= | 32÷2= | 40÷5= |
| 100÷10= | 30÷2= | 80÷10= | 56÷4= |
| 36÷4= | 72÷3= | 65÷5= | 66÷2= |
| 90÷10= | 46÷2= | 48÷4= | 24÷2= |
| 44÷4= | 50÷5= | 54÷3= | 80÷5= |
| 78÷3= | 80÷4= | 51÷3= | 60÷5= |
| 55÷5= | 82÷2= | 100÷5= | 88÷4= |

SAMPLES OF CHILDREN'S TEST SHEETS

Least ability group



Mental Maths Challenge

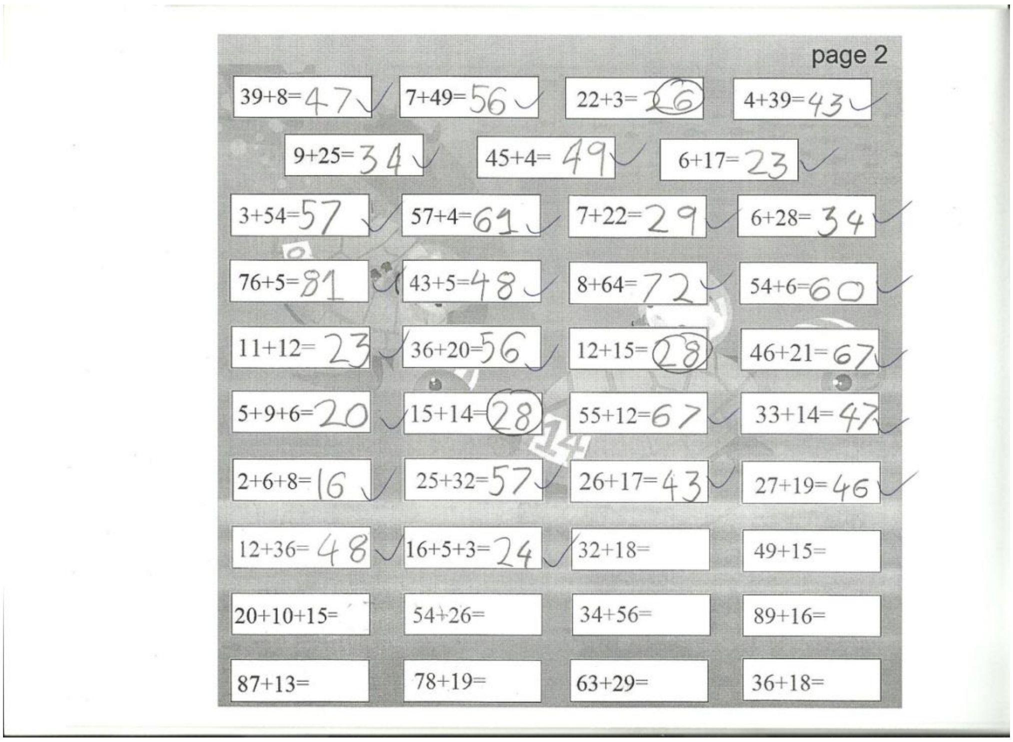
Time: 20

46/50

Name: Age: 7 boy/girl

| | | |
|---|---|---|
| 3+7=10 ✓ | 3+5=8 ✓ | 12+6=18 ✓ |
| 2+3=5 ✓ | 3+6=9 ✓ | 4+9=13 ✓ |
| 5+8=13 ✓ | 5+9=14 ✓ | 7+7=14 ✓ |
| 4+13=17 ✓ | 8+8=16 ✓ | 6+7=12 |
| 3+14=17 ✓ | 6+21=27 ✓ | 40+9=49 ✓ |
| 3+14=17 ✓ | 2+18=20 ✓ | 17+4=21 ✓ |
| 15+4=19 ✓ | 5+18=23 ✓ | 8+20=28 ✓ |

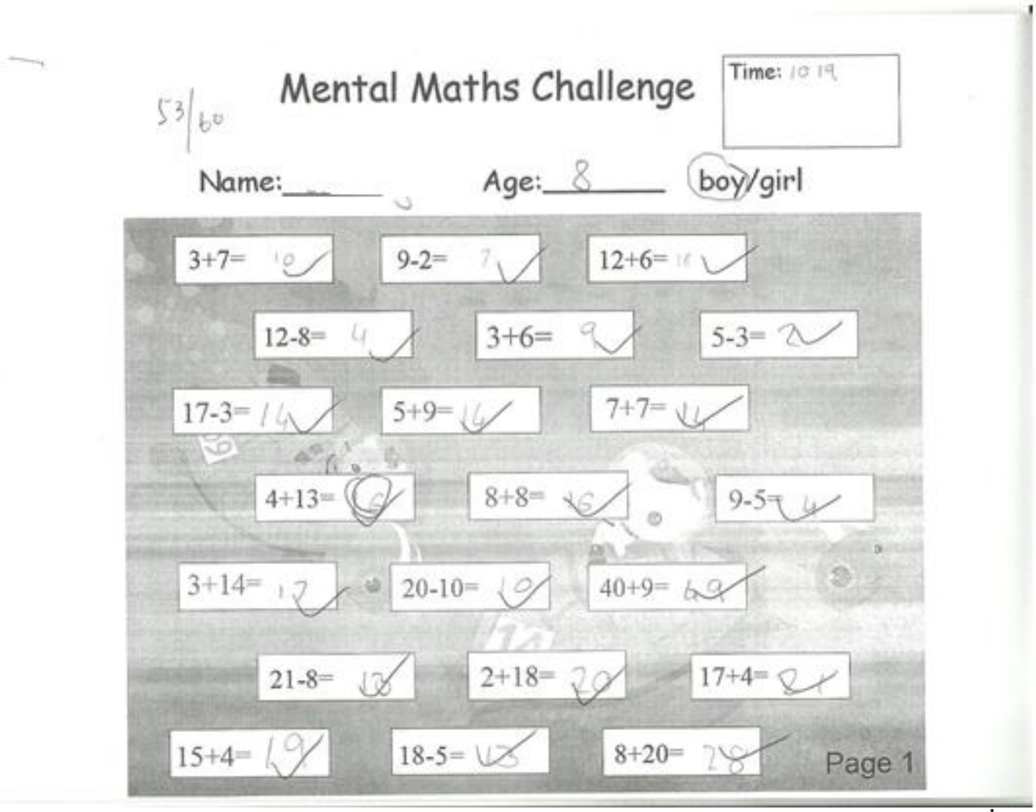
Page 1



page 2

| | | | |
|---|---|---|---|
| 39+8=47 ✓ | 7+49=56 ✓ | 22+3=26 | 4+39=43 ✓ |
| 9+25=34 ✓ | 45+4=49 ✓ | 6+17=23 ✓ | |
| 3+54=57 ✓ | 57+4=61 ✓ | 7+22=29 ✓ | 6+28=34 ✓ |
| 76+5=81 ✓ | 43+5=48 ✓ | 8+64=72 ✓ | 54+6=60 ✓ |
| 11+12=23 ✓ | 36+20=56 ✓ | 12+15=28 | 46+21=67 ✓ |
| 5+9+6=20 ✓ | 15+14=28 | 55+12=67 ✓ | 33+14=47 ✓ |
| 2+6+8=16 ✓ | 25+32=57 ✓ | 26+17=43 ✓ | 27+19=46 ✓ |
| 12+36=48 ✓ | 16+5+3=24 ✓ | 32+18= | 49+15= |
| 20+10+15= | 54+26= | 34+56= | 89+16= |
| 87+13= | 78+19= | 63+29= | 36+18= |

Middle group



53/60

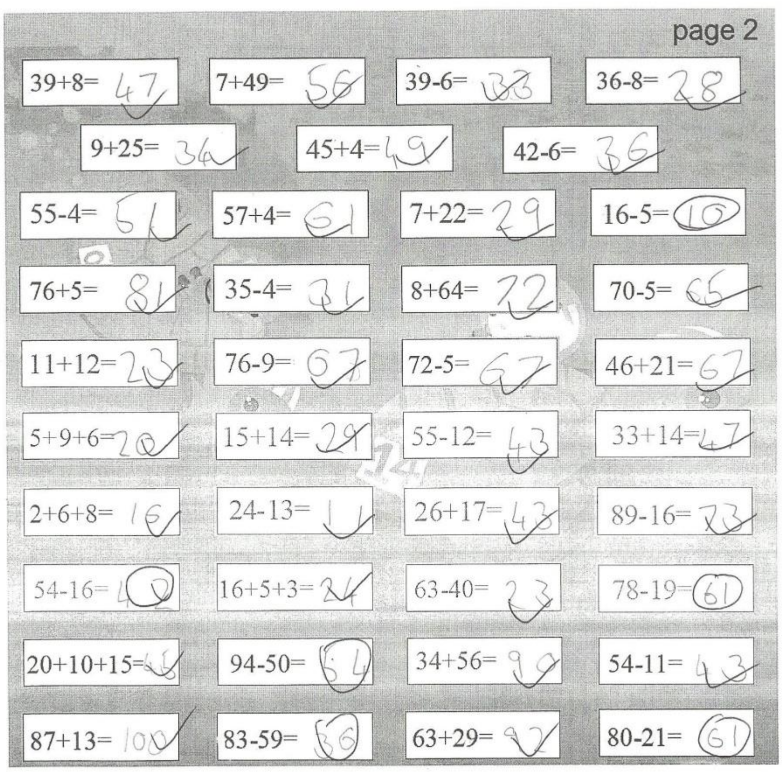
Mental Maths Challenge

Time: 10 19

Name:_____ Age: 8 boy/girl

3+7= 10 | 9-2= 7 | 12+6= 18
12-8= 4 | 3+6= 9 | 5-3= 2
17-3= 14 | 5+9= 14 | 7+7= 14
4+13= 16 | 8+8= 16 | 9-5= 4
3+14= 17 | 20-10= 10 | 40+9= 49
21-8= 13 | 2+18= 20 | 17+4= 21
15+4= 19 | 18-5= 13 | 8+20= 28

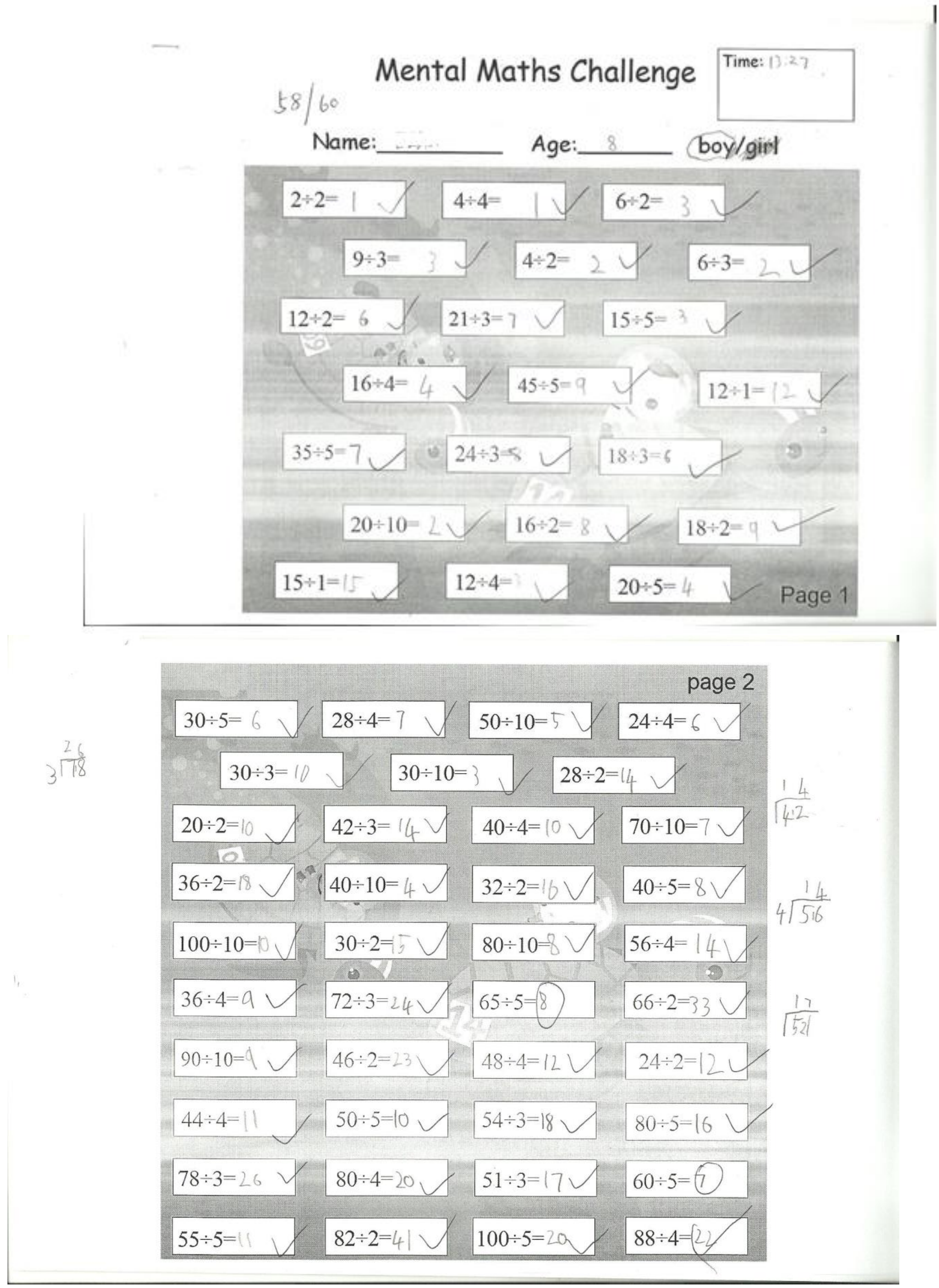
Page 1



page 2

39+8= 47 | 7+49= 56 | 39-6= 33 | 36-8= 28
9+25= 34 | 45+4= 49 | 42-6= 36
55-4= 51 | 57+4= 61 | 7+22= 29 | 16-5= 10
76+5= 81 | 35-4= 31 | 8+64= 72 | 70-5= 65
11+12= 23 | 76-9= 67 | 72-5= 67 | 46+21= 67
5+9+6= 20 | 15+14= 29 | 55-12= 43 | 33+14= 47
2+6+8= 16 | 24-13= 11 | 26+17= 43 | 89-16= 73
54-16= 40 | 16+5+3= 24 | 63-40= 23 | 78-19= 61
20+10+15= 45 | 94-50= 54 | 34+56= 90 | 54-11= 43
87+13= 100 | 83-59= 36 | 63+29= 92 | 80-21= 61

Top group



Mental Maths Challenge

Time: 13:27

58/60

Name:__________ Age: 8 boy/girl

| | | | |
|---|---|---|---|
| 2÷2= 1 | 4÷4= 1 | 6÷2= 3 | |
| 9÷3= 3 | 4÷2= 2 | 6÷3= 2 | |
| 12÷2= 6 | 21÷3= 7 | 15÷5= 3 | |
| 16÷4= 4 | 45÷5= 9 | 12÷1= 12 | |
| 35÷5= 7 | 24÷3= 8 | 18÷3= 6 | |
| 20÷10= 2 | 16÷2= 8 | 18÷2= 9 | |
| 15÷1= 15 | 12÷4= 3 | 20÷5= 4 | |

Page 1

page 2

| | | | |
|---|---|---|---|
| 30÷5= 6 | 28÷4= 7 | 50÷10= 5 | 24÷4= 6 |
| 30÷3= 10 | 30÷10= 3 | 28÷2= 14 | |
| 20÷2= 10 | 42÷3= 14 | 40÷4= 10 | 70÷10= 7 |
| 36÷2= 18 | 40÷10= 4 | 32÷2= 16 | 40÷5= 8 |
| 100÷10= 10 | 30÷2= 15 | 80÷10= 8 | 56÷4= 14 |
| 36÷4= 9 | 72÷3= 24 | 65÷5= 8 | 66÷2= 33 |
| 90÷10= 9 | 46÷2= 23 | 48÷4= 12 | 24÷2= 12 |
| 44÷4= 11 | 50÷5= 10 | 54÷3= 18 | 80÷5= 16 |
| 78÷3= 26 | 80÷4= 20 | 51÷3= 17 | 60÷5= 7 |
| 55÷5= 11 | 82÷2= 41 | 100÷5= 20 | 88÷4= 22 |

APPENDIX L: QUESTIONNAIRE ABOUT CHILDREN'S ATTITUDE TOWARDS PLAYING ONLINE MATHEMATICS GAME

| Name | Age | Boy or Girl |
| --- | --- | --- |
| | | |

## Questionnaire

Q1. Do you like playing the online mathematics games?

A. Very much

B. A bit

B. Not sure

D. Not very much

E. Not at all

Q2. What's your feeling towards the online mathematics games?

_______________________________________________________________

_______________________________________________________________

_______________________________________________________________

Q3. Which game do you like most?






A. B. C. D. E. F.

Q4. Why do you like the game?

__________________________________________________________

__________________________________________________________

__________________________________________________________

Q5. Do you think you have improved your mathematics through playing games?

A. Yes B. No

Q6. Why do you say this?

__________________________________________________________

__________________________________________________________

__________________________________________________________

Q7. Can you work out answers more quickly through playing games?

A. Yes B. No

Q8. Would you like to continue learning mathematics through playing games?

A. Yes B. No

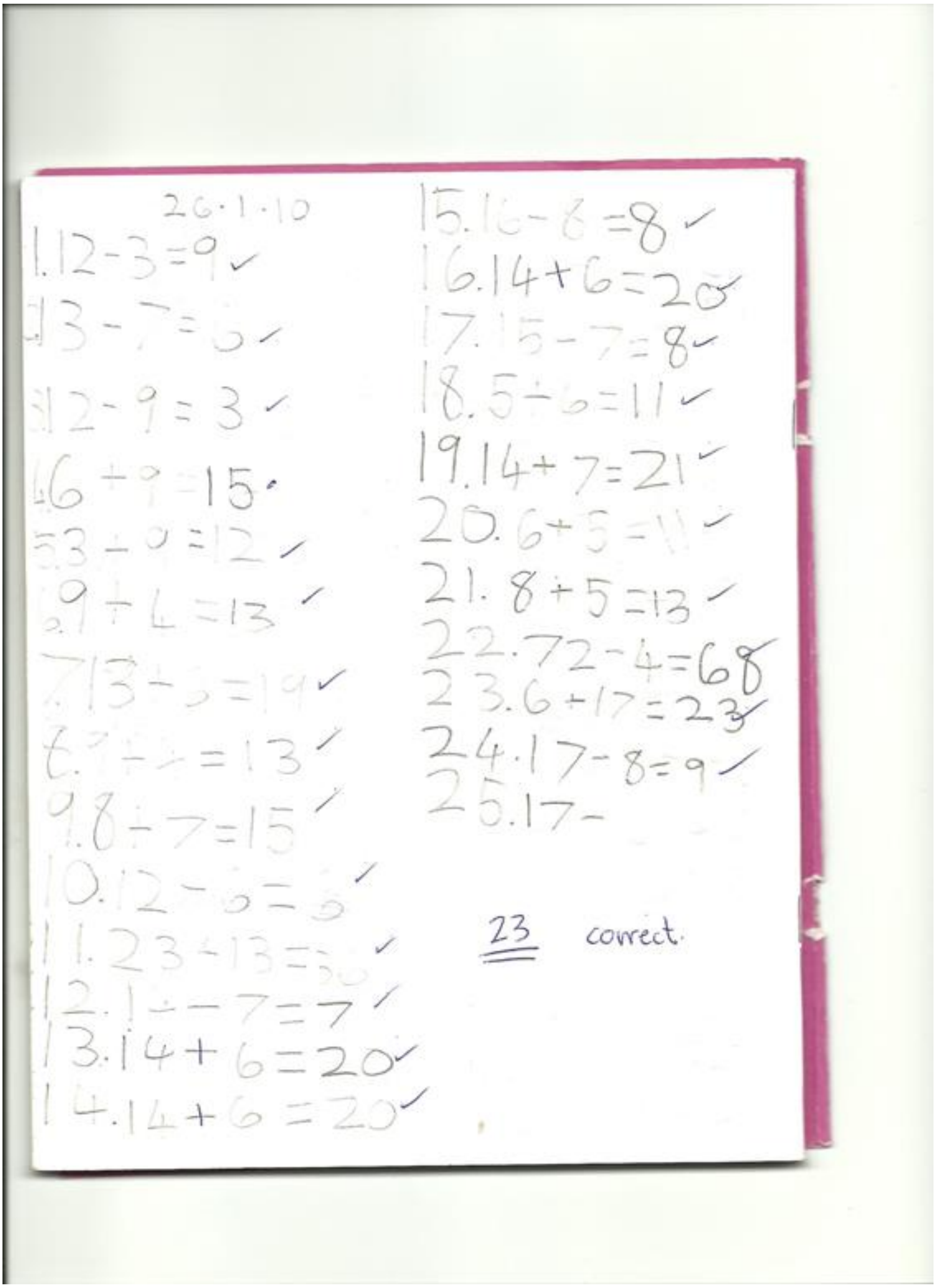
Q9. Why do you say this?

__________________________________________________________

__________________________________________________________

__________________________________________________________

APPENDIX M: SAMPLE OF CHILDREN'S PAPER-PENCIL GAME WORKSHEET



26.1.10

1. 12-3=9 ✓
2. 13-7=6 ✓
3. 12-9=3 ✓
4. 6+9=15 ✓
5. 3+9=12 ✓
6. 9+4=13 ✓
7. 13+6=19 ✓
8. 7+6=13 ✓
9. 8+7=15 ✓
10. 12-6=6 ✓
11. 23+13=36 ✓
12. 14-7=7 ✓
13. 14+6=20 ✓
14. 14+6=20 ✓
15. 16-8=8 ✓
16. 14+6=20
17. 15-7=8 ✓
18. 5+6=11 ✓
19. 14+7=21 ✓
20. 6+5=11 ✓
21. 8+5=13 ✓
22. 72-4=68
23. 6+17=23 ✓
24. 17-8=9 ✓
25. 17-

23 correct.

APPENDIX N: OBSERVATION SHEET

Date： 2010.3.26 No of children: 4 (one girl and three boys)

Children played the game in the school corridor on the same floor, and close to children’s own classroom. There were four computers on the four rectangular desks with four chairs in the left side and two computers on a big corner table with three chairs in the right side. There were one printer, one copy machine and some storage boxes in the middle. The light in the corridor was a bit dark but did not seem to affect children’s gaming playing. The class teacher made sure all four children were sitting at the computer, then went back to classroom.

The Capital letter A, B and C were used to identify three boys on the observation. The children sat as the following position.

| | | | |
|---|---|---|---|
| Girl | Boy A | Boy B | Boy C |

| Time | Environment observed | Action observed |
|---|---|---|
| Start | The corridor was quiet, with no children or adults passing through and no distractions. | All children were sitting around computer and each child logged on the game platform by using their own username and password. |
| About 1 min | | All children looked at their screen and moved their mouse to play the game. |
| About 3 mins | One school child passed through but said nothing to the children | Boy A and C turned their head around and looked for a few seconds and then back to look at the screen to play the game. The other two children looked engaged on gaming. |
| About 7 mins | An adult (teacher) came to use the printer nearby the computer. She noticed that children were looking at her in a few seconds. She told children to concentrate on screen by gesture. | All the children were distracted by looking at the adult (teacher) but they did not make a noise. Three of them went back to play the game after the gesture of adult (teacher) but boy A began to flick the table with his finger |

| | | |
|---|---|---|
| | | for a few seconds. He looked bored. He looked at the screen, moving the mouse on the screen but was not trying to answer the question on the screen. |
| About 8 mins | | The girl said "oh" in a *whisper*. A red cross on the screen. She clicked the button 'next' quickly to try next question. Boys did not hear. The boy A still sat there and did not play the game. But he leaned back in his chair and put his hands on his thigh. |
| About 9 mins | | The game on the screen finished automatically. Boy A began to move his mouse to choose a new game to play. |
| About 10 mins | The adult (teacher) left.<br>The corridor was quiet. | All children played the games and looked engaged with the screen and work diligently. |
| About 13mins | A school boy passed through the corridor. He said 'Hey' to children and stood beside one child to look at screen and talk. | All children were laughing and all of them turned their head around to look at the boy. The girl and boy C looked for a second and then back to their screen. Boy B chatted with the school boy. Boy A looked at them all along but did not join the conversation. |
| About 14 mins | The school boy said 'bye' and left when he found the researcher were sitting there. | All children looked at him again. The girl and boy C were back to their screen at once. After the boy left, two boys A and B began to chat 'I like this''I got past level two''click rocket, rocket''oh, no, it's twenty' |
| About 16 mins | The corridor was quiet, with no children or adults passing through and no distractions. | All children looked engaged on gaming |
| About 17 mins | | Boy A said 'come on' and closed the game without the game being finished and opened a new one quickly. Perhaps the game seemed too hard for him. |
| About 21 mins | | All children left the computer and went back to the classroom by themselves |

APPENDIX O: TEACHER'S INTERVIEW

The setting for the interviews was in a classroom. Teacher was sitting beside the researcher and her supervisor. The children were looking at the video at the same time. The interview was conducted in the afternoon on 12th May 2010. The interview was in informal and friendly atmosphere where the teacher was informed that interview will be taped by voice recorder to help remember what she said but all the information in this interview would be held securely and only for this particular study.

In order to find out more details about children's online game playing and teacher's views on using games in the classroom, some pre-set questions were prepared before interview and listed below:

- How well are the children achieving?
- What is the children's engagement in gaming and the paper-pencil card game?
- When children play the online game, do they ask for help?
- Do children try to get a higher score or try to beat friends' scores?
- Any difficulty in using the online game in the classroom?
- Will you use the game instead of a textbook?

Extracts of Teacher's interview transcript

Note: When the recording was replayed, the quality of the sound was variable. I will miss out some sections if they were not clear or they were not relevant to this study.

Researcher: How well do you think the children are achieving after this project?

Teacher: It's very difficult. I haven't seen. I think the children are more confident in their addition and subtraction. As you know these activities which have been going on were a very intense 20 minutes every day and very focused over a six week period. So in this respect I would say the children have some improvement because they were given a rich context for six weeks.

Researcher: When pupils play the computer game, some of them are always outside of the classroom. In the classroom, in your view were they always concentrating on their activity?

Teacher: I had to put the children out to do the computer. When I came back they were a little bit off-task when they were doing written tasks and jotter. They were much better when an adult was in the room beside them because with the adult there, they would concentrate more. The computer game group can be left alone; they just played the game quite diligently but not the written group. (The written group) need an adult sitting in with them. There were two computers available in the classroom, so I chose the children who may cause more problems outwith the classroom and they were in the classroom with me. So with this kind of organisation it made sure that the two people would stay on the task as much on the computer and also if they were in the classroom with the teacher.

But at the start of the study, it was a little difficult to record the time as there was no automatic log out of the computer after 20 minutes. I couldn't manage this study without automatic log out. This was not available initially in the study but the problem was solved earlier on and they all logged out – at different times - but all at 20 minutes.

Researcher: You said that there were 2 children who worked in the classroom on the computer. Were these the same children all the time?

(After checking with children, the teacher said that 2 children played the games in the classroom throughout all of the block, sometimes there were 3 children depending on concentration.)

(Teacher started to say why these children were chosen for the classroom)

Teacher: The reason for A was she has reversal problem with numbers. She does reversal with the numbers, meaning instead of "64" she will write "46". If I am not there then she will get stuck with the '64' to '46'. She gets mixed up.

B needs to be the classroom for concentration.

C was another one who came to the classroom at different times because of behaviour, as was D, and as was E.

Researcher: When they played the computer game, do you help them?
Teacher: If they ask for help, or they get it wrong a lot of times, I will remind them again how to do it.

Researcher: What's your intuition, your feeling about how engaged they were with the computer game, do you think they were more engaged with the task or was it a different sort of engagement?

Teacher: I thought they were engaged but that is not to say that they were doing more. They were engaged on the screen but could be working at a slow pace. They may have been doing more written work because I was here with them. This probably helped them to stay engaged as well and a lot of them manage to fly through the sums. So when using the computer they could go at any pace but look to be engaged. I didn't know what they were doing because I necessarily had to wander back and forward to check and make sure everything looked OK. Children in here, they could be sitting at the screen, clicking the mouse anywhere really, although when I did look they appeared to be definitely carrying out the game, although I don't know by the speed. There was no written evidence of the speed whereas I have evidence of the speed with the jotter work.

Researcher: When the children did the task using the cards, they wouldn't get immediate feedback; they get that later on. Did you get any thoughts about that?

Teacher: I did examples of types of sums on the board. I went around and made sure (children) remember - if you are borrowing, you have to borrow there…(teacher made sure children remembered how to do sums). But I wasn't sitting down to say oh no, that's wrong, this is what you should be doing.

When I mark the error which was being repeated throughout that session then I will talk to the child before the next day and say 'you got this, this wrong because... (help the child to understand what was wrong)' and do a lot of examples on the white board. These will make more sense (for this child) to be ready for the next day. And I made sure that I did a teaching point after each day.

Researcher: Did the children review their worksheet of the card activity?

Teacher: I always give them their score. How many they got correct. They were always trying to match the score or to get more next time. I did this for both studies.

Researcher: So pupils will take a look at their records (of the jotter work) and then make a new attempt?

Teacher: Yes. That's something we didn't have on the computer. But, it was the same with both groups. Both groups didn't have that on the computer; both groups did have in the jotter. So it was the same for both groups.

Researcher: Do you know whether pupils liked to know their score in the computer?

Teacher: They tried to access it a lot of times, they were keen to see what they had done. But of course we couldn't get access…tried everything, but nothing.
Researcher: So the pupils like to know this?

Teacher: Yes. Just as I said but they couldn't view the score, oh! They were keen to but they couldn't, oh! They were disappointed, but they still did the tasks which I asked them to do even though they couldn't see the score. They were still enthusiastic to do it. They were interested in […unclear…] to see how well they've done.

Some games automatically showed the cross to let them know they were wrong. But like the rocket one, I don't think it let them know. What the children were doing, just clicking the rocket until they clicked the right one. They didn't have to work anything out, they just kept clicking until they get the right one. Some of them did not understand that. I said to them if you keep doing that you will not get on to the next level. After that they may be more diligent to choose the correct rocket.

Researcher: How will you use the computer program after the end of this study?

Teacher: I will use the same set up for the mental maths. We will do class mental in the morning. (I will) always change the game to help (children make) progress through the learning, like reinforcement exercises for them, just make sure they could apply all the skills I taught to them. (I will use) different context on the computer, use Nintendo's again, and then the resource like the way you see with the assessment again. You can use same resource in different ways because they were not known that what they did. That was not boring to them. […unclear…]As jotter work (in this study), I marked, pointed out the mistake, but when we go around today to look what they have done, they still need help with something, it still useful for them.

It was just a different way of presenting the same thing, so the resource can last as long time as you choose the different way to keep them interest. […unclear…], pupils completed it, teacher marked it, the pupils compete my mark, then the children use the resource. As I said to them today, in one or two weeks we will does an exercise 'show your partner'. The children should find out the answer themselves, check each other using calculator, whiteboard, that was a lot of work, one present like a teacher, others learning from their peers.

Researcher: When they are doing the activity work, do they compete with each other?

Teacher: For the way we did (the project) the children were competing against themselves. Because we always try to better the score from the day before rather than beat somebody else, we tried to beat our own score when we did the jotter.

In the classroom, they had to finish in 15 minutes. Some of them never, never got through all the sums and the boxes because in just 15 minutes. They did have a competition with the time to try to get as many done as they could within the 15 minutes.

They knew they were getting closer because of the pile they had left, then they will be working fast, but not against anybody else, more against themselves, I would say.

Researcher: Would the children ever ask for help from their classmates?

Teacher: No. They were not allowed to do that because it was their own work. You can ask for help with the activity work.

Researcher: In your view, what was the main difficulty in managing the computer game with pupils?

Teacher: The first difficulty was that I didn’t know when 20 minutes was up. But it was really fine when (the games) were able to time out after 20 minutes.

At the start I was just teaching how to log on and you know, how to play the games, within the first week, until they played all the games. The first week was the worst because sometimes they didn’t know what to do. The speed of rocket game was too fast. The rocket was buzzing and they couldn’t pinpoint the answer. That was 2 difficulties. It was easily fixed because you can slow down the speed. After they knew how to play the games, (they) became confident on the computer. I just had to send them to it and it didn’t become an issue to manage that side of things at all.

Behaviour, sometimes, that’s the benefit having your computers in the classroom as well. You can select which pupils you want to stay in the classroom and which pupils you trust enough to work independently.

There were always some things which did not quite get done as they will speak to their peers when they are out of the classroom. Because of this sometimes they didn't get much done. There is some distraction if there is no teacher there, there can be kind of more conversation to each other than in the classroom. So maybe the ones in the classroom will be on task with the computer for longer than the ones out of the classroom only.

Researcher: The computer game – is it ok for teaching or just really for practice?

Teacher: Practice. Because I have already done the teaching with the class, then I can choose the games relevant to teaching I have done. The whole study has been revision rather than teaching, it’s because some children are always behind and need to be taught by me in the classroom.

Researcher: In the future, how will you use the computer game?

Teacher: I don’t think I will use a computer to teach the children how to do particular types of sums and I will always be the one to teach them how to do it first, then they can go to the computer to reinforce my teaching. I wouldn’t allow a computer to do the teaching…I wouldn’t get across a new concept by using the computer.

Researcher: Do you prefer using computer games or textbooks for children to practise?

Teacher: I will use a mixture of the two. I will never just use computer to do reinforcement. I'd like to see children's written work for the purpose from parents and (keep) records of the children have actually done some written work, for presentation purposes I'd like them to do written as well. I wouldn't have all written... (for example) I will take a session in the textbook and maybe three on the computer. But like** (a child's name), for example, it's good to get children to do written because ** (a child's name) reverses in written work as well, you need to see, actually physically see, whether children have a problem, …, the jotter will pick this up. It's not easy to see the problem on the computer…you don't have a physical enough resource with the computers…the Nintendo idea where you can write on the screen - I will go down the line like that to replace the textbook, but I will not go down the line like a game approach replace the written work.

(The interview stopped for a while because children were getting ready to go home)

Researcher: (As you said) there was no competition with each other, but did they help each other when they were playing computer games?

Teachers: Not that I am aware of. In the classroom, they come to me if they are stuck. Even children in the outside area, if they were stuck, they would come to the classroom and say 'I am stuck'. I would go outside to help. It happened in the initial stages. But once they got used to the games, it became easier and less children were stuck, except ** (a child's name), which is why she was in the classroom. And ** (a child's name) who has difficulty anyway, and that's why he was in the classroom. If they were stuck, there will be a helping hand right away.

To start with, (children) had headphones on because the game was noisy. For the ones in the classroom, they had headphones all the time because the others need quiet to do their jotter work. And sometimes for the children in the (corridor) area another group were working nearby; (the children) had to set headphones on. Sometimes just turn the volume off…They didn't speak to anybody around them.

(Now the interview was supposed to be finished. But when I talked about the findings, that the children with jotter work improved more than the computer game, the teacher stated more opinions about that.)

Teacher: The only thing about the computer is you don't know exactly the speed. You don't have much evidence of performance on the computer game because there was no evidence of what they had done. Because there were no scores even, I couldn't get access to see how many games they played, or anything like that.

Researcher: I suppose the argument in favour of the computer game will be the structure of the program, the activity was motivating, they want to do it. The fact you have not got some kind of record is unfortunate. But if it was not central to the game then the game would not have this capability.

Teacher: The only thing with the space rocket game, when I observed them one time they clicked any rocket then they finally got the right answer. That type of thing doesn't give them practice. The jotter work people were getting this because they knew I would see it at the end of day…That's the one game I remember. It looked impressive because the speed was going up. From my distance they looked like they were doing very well and really focused on…They didn't seem to realise the way they get progress in the game. Although the rocket just came on the screen looked the same. I do not think they were aware of advancing to another level. They didn't realize what they were doing, the screen just came out and everything looked the same. They just thought if I keep clicking to get the right answer it moves me on.

I think it would benefit from if it was wrong there is a way they know they are wrong like the one with the cross (another game). They knew they'd done something wrong. But with that one, that particular game, it's wrong, wrong, wrong and right, find the right answer. Speeding, they just thought of the time thing - they panic and have to be done and find it quickly, like a treasure hunt, they didn't care about competition; they just have to find the right rocket. That's an example that I can think of that didn't work well as the other game.

Some games try to move the firefly, if it's the wrong answer the firefly will fly back. It's still guesses as well. The only one that didn't have any elements of guess work, maybe it's wrong to say that, I just feel the one tick and crosses, the normal type of sum, encourages them to use hundred [unclear] or other devices than that one guessing work.
Researcher: If the pupils could see the history or their scores or speed on the computer, would this motivate them to play?

Teacher: I would imagine that it would, but I don't know because they didn't get a chance to see, but I am trying to think about an example with the jotter work – they knew what they got last day because I wrote the score. They knew they were getting better, that is the only comparison I can make. They were keen to do that.

**(a child's name) was always keen to get through every single ticket [unclear] in the box. He wanted to get them all done. Two or three occasions he did get them done. He was happy, but then what I feel is 'what can I offer you now?' All I could say was start again. You know， with only ** (a child's name) can do it, with only 2 or 3 times, but I wondered what you (the researcher) were thinking once he did get to the end…(But because) others children just never got end of the pile, so that could not an issue for arranging what to do next.

# APPENDIX P: CONSENT FORM FOR PARENTS

October, 2009

Dear Parent,

I am a PhD student in the School of Education, Social Work and Community Education at Dundee University. I am undertaking research into how electronic games can be used in primary schools. I am interested in exploring how using computer games as part of children's mathematics work could support their mathematics learning. There is some evidence to suggest that computer games can make children's mathematics learning fun and there is evidence to suggest that it helps with their mental calculations. I want to learn more about how using these games may motivate the children to do mathematics work and hopefully improve their computation.

I have chosen to work with your child's class. A game website has already been set up. The games we will use are computation games. There are some addition, subtraction and division questions in the games. The plan is that children will be randomly assigned to one of two groups. The first group children will play mathematics games for twenty minutes at school every day for four weeks and the group two children will do similar work but in a conventional paper-based way. After four weeks, the two groups will be swapped, and the work will continue for another four weeks. We will measure changes in mathematics scores and their attitudes towards learning mathematics. During the project your child will be asked to do short number challenge tests and they will be asked to complete a short questionnaire. We hope that some children will be prepared to participate in group interviews to talk about their experiences in using these computer games. However, this will be entirely voluntary.

All data records will be held on a password protected network with a back up held in a secure office. Data will not be used for any other purpose than to inform this specific study. Your child's anonymity is guaranteed and the data we collect will not contain any personal information. All data will be coded in order to protect child's identity. The researcher may access data and quote from it anonymously in future papers (for example, in her doctoral thesis, conference presentations and papers for publications) but at all times the same conditions regarding confidentiality will apply.

Your child's participation in this study is voluntary. There are no known risks for your children in this study. You or your child may decide to stop being a part of the research study at any time without explanation and without any penalty.

I will be glad to answer your questions about this study at any time. If you want to find out about the final results of this study, you may contact me at: m.chen@dundee.ac.uk or 01382381443.

I hope you will agree to allow your child to participate. If so, could you please fill in the consent form to indicate your consent and return it to the school? Please accept my sincere thanks for your co-operation.

Yours Faithfully

Ming Chen

Consent Form

Project title: Games on website for Children's mathematics learning

Project investigator: Ming Chen

Signed:

Please delete as appropriate.

---

I do / do not give my permission for my child to participate in this study.

Print name_____________________ Signed_________________

Date__________________ Child's name___________________

# APPENDIX Q: UREC APPROVED LETTER

UNIVERSITY OF DUNDEE

School of Psychology

**University of Dundee Research Ethics Committee**

Ming Chen,
School of Education, Social Work and Community Education,
University of Dundee,
Nethergate,
Dundee,
DD1 4HN.

1 March 2010

Dear Mr Chen,

**Application Number: UREC 9079**

**Title: Flash games for children's maths learning.**

Your application has been reviewed by the University Research Ethics Committee, and there are no ethical concerns with the proposed research. I am pleased to confirm that the above application has now been formally approved.

Yours sincerely,

Peter Willatts

Digitally signed by Peter Willatts
DN: cn=Peter Willatts, o=University of Dundee, ou=School of Psychology, email=p.willatts@dundee.ac.uk, c=GB
Reason: I am the author of this document
Date: 2010.03.01 16:13:43 Z

Dr Peter Willatts
Chair, University of Dundee Research Ethics Committee